1988 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

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*Ranking Republican Member.
**Resigned February 19, 1987 (H. Res. 89).
***Elected March 30, 1987 (H. Res. 133).
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1988 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

THURSDAY, FEBRUARY 19, 1987

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Science, Research and Technology,
Washington, DC.

The Subcommittee met, pursuant to notice, at 9:35 a.m., in room 2318, Rayburn House Office Building, the Honorable Doug Walgren (Chairman of the Subcommittee) presiding.

Mr. Walgren. Let us begin and we will be joined shortly by the ranking minority member, Congressman Boehlert from New York. I want to particularly welcome Congressman Nagle and Congressman Hayes, new members of this Committee, and others that will join us, but inasmuch as this is the first meeting of our Subcommittee, it should be said at the outset how pleased I am that we have the members, having selected this Subcommittee, we have a most exciting jurisdiction; one that is central to the national interest and the particular quality of the people who choose to serve on this Subcommittee is something that I think deserves recognition.

As Chairman of the Committee in years past, the quality of the people that came on it this year certainly will require all of us to do better and to reach up a little higher to fulfill the responsibility that we have as, in my situation, as Chairman, and staff support for the Committee. And I just want to say how much I think of their having chosen to serve on this Committee, and that goes for everyone and I look forward to this year with great expectation.

This is the first hearing on the National Science Foundation's authorization for fiscal 1988, and it will focus mainly on issues pertaining to science education. In the past several years, public awareness of the importance of science and math education, and particularly our shortcomings in that area as a nation, has grown dramatically.

The panel this morning will address the impact of the fiscal 1988 NSF budget on programs in this area, in both pre-college and undergraduate levels.

We are pleased to have as witnesses Dr. Homer Neal, who is the Provost of the State University of New York at Stony Brook, and who most recently has served as Chairman of the National Science Board Task Committee on Undergraduate Science and Engineering Education. Dr. Neal and his group have put together a most significant review and series of directions for the nation on undergraduate science and engineering education, one that we are going to be pursuing, along with the NSF to see that its objectives are fulfilled.

Along with Dr. Neal, we have Mr. LeRoy Lee, the Executive Officer of the Wisconsin Academy of Sciences, Arts and Letters. Mr. Lee is the President of the National Science Teachers Association, and we also have Dr. Joan Straumanis, the Dean of the Faculty at Rollins College, who is testifying on behalf of the Associated Colleges of the Midwest along with the Great Lakes Colleges Association and a number of independent colleges.

The steady decline at all grade levels of student achievement in science and math and the projected shortfall of science and engineering graduates are disquieting to say the least, particularly coming at a time when we are more than ever realizing the importance of technological excellence in international economic competition. These trends must be reversed, not only to ensure that the pipeline of scientists and engineers is full, but also to improve the general scientific awareness and literacy of the American people as citizens.

To sustain itself, a technologically advanced society requires that the scientific literacy of the workforce remain high. Public policy questions increasingly revolve around issues that need a general science literacy to be understood. Inasmuch as our society takes direction from its citizens, that cannot be underestimated. I think you see in the day to day news an awareness of our shortfalls.

The President wants to say these days that when the year 2000 comes he wants our country to be at the head of the class and the top of the charts. Nothing will determine more where our country is at the turn of the century than the science education effort that was made in the early 1980's, and in truth we all now recognize that we, at a national level, turned away from our responsibilities in science and engineering education in that period, and now are coming back to it.

It should be no surprise, that a country like Japan, whose educational effort is so much more complete than ours in science and engineering education and which obviously has so much more discipline than our effort does, is applying our results of research and innovation better than we are applying our scientific progress. It may be as simple as the fact that they have a more scientifically educated population. Certainly they're graduating more engineers than we are now, and in certain disciplines they are the ones that apply; the electronics of computer related economic products, and that should not be a surprise to us.

The witnesses that we have this morning will address the National Science Foundation's role and the degree to which the Foundation is effective in that role in improving the level of pre-college and undergraduate education in math and engineering and the sciences. We certainly have to focus on that federal role through the National Science Foundation.

We can't but be struck that in response to Sputnik in the 1960's we had a National Science Foundation focused effort on education through their science and engineering education directorate, that would be measured in present terms at something in the range of $250 million a year. We are presently reaching up and trying to spend $115 million according to the new proposal in a focused way through the science and engineering education directorate, and you have to ask yourself in measuring the challenge that Sputnik provided for our system and measuring the contribution that we know science and engineering education has to make in the future whether that is an adequate response.

With that for opening comments, let me ask my colleagues who've joined us whether they would like to say anything at the outset. Congressman Lee and Congressman Sabo—I'm sorry, Congressman Chapman, Hayes, I'm sorry. Well we have—we would ask unanimous consent that any cameras and recording of this session be permitted. A technicality under the rules, but one that we certainly have no problem with in general. And without objection, that will be the order.

Well, let me first then turn to Congressman Martin Sabo from Minnesota. Congressman Sabo has been a valued and interested member in science and technology and has a very specific concern that he wants to raise with the Committee this morning. We appreciate your being here, and would welcome your participation in this whole area, and your written statement will be made part of the record as a matter of course, but please feel free to develop your subject in any way that you see fit.

Welcome to the Committee.

[The prepared opening statement of Mr. Walgren follows:]

Opening Statement of Congressman Doug Walgren (D-PA), Chairman, Subcommittee on Science, Research and Technology on the National Science Foundation Authorization Hearing—February 19, 1987

This is the first hearing on the National Science Foundation's authorization for fiscal year 1988. It will focus mainly on issues pertaining to science education. In the past few years, public realization of the importance of science and mathematics education to the health and well-being of the nation has grown. The panel this morning will address the impact of the fiscal year 1988 NSF budget on programs and initiatives affecting science, mathematics and engineering education at the precollege and undergraduate levels.

We are pleased to have as witnesses and welcome Dr. Homer Neal, Provost of the State University of New York at Stony Brook and Chairman of the National Science Board Task Committee on Undergraduate Science and Engineering Education; Mr. LeRoy Lee, Executive Officer of the Wisconsin Academy of Sciences, Arts and Letters and President of the National Science Teachers Association; and Dr. Joan Straumanis, Dean of the Faculty at Rollins College.

The steady decline at all grade levels of student achievement in science and mathematics and the projected, significant shortfall of science and engineering graduates are disquieting trends, particularly at a time when the importance of technological excellence in international economic competition becomes more and more obvious. These trends must be reversed not only to ensure that the pipeline of scientists and engineers remains filled but also to improve the general scientific literacy of the American people. To sustain itself, a technologically advanced society requires that the scientific literacy of the workforce remain high. Moreover, public policy questions increasingly revolve around issues which cannot be understood, let alone resolved wisely, in the absence of general scientific knowledge.

The distinguished witnesses this morning will address NSF's role, and the degree to which the Foundation is effective in that role, in improving the level of precollege and undergraduate education in mathematics, engineering and the sciences. We are interested in learning their views on the current activities of NSF, as well as on the implications of the allocation of funding in the fiscal year 1988 budget.

First, I want to welcome my colleague, Congressman Martin Sabo of Minnesota, to the Subcommittee. Mr. Sabo has been actively interested in university research issues, particularly advanced scientific computing.

STATEMENT OF THE HONORABLE MARTIN O. SABO, REPRESENTATIVE IN CONGRESS FROM THE FIFTH DISTRICT OF MINNESOTA

Mr. SABO. Thank you for letting me appear before you today. As you begin your hearings under your authorization for the NSF. I served as a member of the HUD/Independent Agency Subcommittee for Appropriations from 1979 until last May. As most of you know, that is the Appropriations Subcommittee which deals directly with the NSF budget, and during my eight years on that Committee, NSF was always one of my favorite agencies, and I watched their programs with keen interest.

However, the Foundation is now embarked on a path in one area which I think is mistaken, and I would like to share my concerns with you. The area which concerns me is the advanced scientific computing program.

As a representative from the city which houses the corporate headquarters of this country's supercomputer companies, and one of the nation's leading supercomputer centers, I've been especially interested in this area. Since supercomputer technology is relatively new and rapidly evolving, it is important that we keep an open mind when looking at ways to use this technology. I believe NSF has set itself upon a very limited and limiting track in developing this program, and I believe the Foundation is making some very serious mistakes in this area.

First I'd like to review some history with you, so we can see where we have been to better assess where we should be going. In 1984, the NSF came before your Committee, and the Appropriations Committee, and requested $20 million for an advanced scientific computing initiative. Your Committee reacted very positively to this proposal, and in fact you responded with much more force and vision than the Foundation had shown. In your report on the authorization bill for the NSF in March 1984, you noted, and let me quote,

> The Committee believes that strong initial support, as well as adequate continued funding is essential for the development, implementation and continuation of a program to provide the immediate and long range needs for advanced computing services to the U.S. science and engineering research community. To ensure that an effective program is developed, mechanisms should be established to facilitate the exchange and use of the latest computer developments among physicists, chemists, biologists, and many other researchers, as well as computer scientists and electrical engineers.

Your Committee requested that this initiative be carried as a line item in the Foundation's budget. You tripled the program from $20 million to $60 million. Funding for the program was cut back in the appropriations process. Finally, you ended up at $41.4 million. Obviously, the Congressional committment was very high. With subsequent appropriations of $46 million in 1986, and the House recommendation of $55 million for fiscal 1987, that committment has been reiterated. The 1987 level was reduced after the continuing resolution made a general cut of $73 million in the NSF's budget. The NSF, however, took a much larger share of that cut, out of supercomputer programs than they represent in the total NSF budget.

In 1984 when the initiative was developed, the Foundation was paying for access to available supercomputers for its researchers who needed supercomputing time. They did this by contracting for time with existing centers. Three were in academic situations, the University of Minnesota, Colorado State University and Purdue University. Three were in business settings, Boeing Computer Services, AT&T Bell Labs, and Digital Productions. These six centers were called Phase I resource centers. (In this discussion I will be referring to the academic centers only.)

In its initiative, the Foundation proposed to develop a limited number of national supercomputer centers which would be designated as sites for use by NSF researchers and grantees. These sites were to be selected through a national competition. This competition was held and three academic sites were selected. Two were added later, and these institutions, Princeton, San Diego, Illinois, Cornell, and Pittsburgh now compromise the Phase II centers for national advanced scientific computing.

In 1984, when your Committee reviewed this initiative, your report cited a study that said there was an immediate need for two large scale machines, by science and engineering researchers. This report, the Borden/Curtis Report, further stated that as many as ten of these machines would be needed by researchers in the near future, and that at present many U.S. researchers are obliged to carry out their advanced scientific computation at foreign facilities.

Dr. Knapp, the Director of the NSF in 1984, reported to the Appropriations Subcommittee that there was virtually unanimous agreement that important science is not being done because academic scientists and engineers have limited access to computational resources. The need for access to supercomputers in a variety of disciplines are not well specified or understood. Yet it is likely that they will never be identified fully until scientists have much better access than at present.

We have since learned how farsighted his remarks were. For the last three years, NSF has funded the Phase I resource centers, at a modest level, as it has worked to build up its Phase II National Centers programs. NSF has always said it would stop funding Phase I centers when the Phase II centers were completed. In that same time we have seen a virtual explosion in the understanding of supercomputing possibilities. Scientists all over the country are just beginning to realize the incredible work that they can do with this technology.

In 1986, NSF decided that it could no longer afford its Phase I centers, even though the Phase II centers were not completed. It has summarily denied access to Phase I centers for its researchers. In fact, the University of Minnesota was told on Wednesday, February 11, 1987 that it had to close down all its NSF accounts by Friday, February 13, 1987, a two-day notice, not only to the University, but also to the researchers who were in mid-research, in the middle of research projects.

Up until that point, the University of Minnesota staff thought they were negotiating with NSF. I don't know all the details of their discussions, but two days notice hardly seems fair, either to the center, or its 334 NSF users.

For the record, Mr. Chairman, I would like to submit a chart which indicates the universities that other researchers come from, and the number from each of those universities who are using the Minnesota resource center.

[Information attached.]

NSF USER SUMMARY BY INSTITUTION FOR DECEMBER, 1986

Institution	Number of grants	Allocation
MIT	11	$739.74
Cornell University	5	539.00
Wayne State University	3	252.63
SUNY, Stony Brook	3	170.00
University of Arizona	5	275.00
University of Minnesota	34	2313.00
New York University	7	442.00
Johns Hopkins University	4	38.00
Harvard University	6	706.71
University of California, Santa Barbara	1	12.00
Carnegie Institution of Washington	1	200.00
Carnegie-Mellon University	4	55.00
University of Wisconsin, Madison	8	75.00
National Opinion Research Center	1	85.00
National Bureau of Economic Research	2	30.00
University of California, Berkeley	7	236.34
University of Pittsburgh	3	263.00
Columbia University	2	670.00
University of Chicago	8	373.40
Iowa State University	4	145.00
Wesleyan University	1	14.00
Texas A & M University	2	51.26
University of Texas, Dallas	1	25.00
University of Texas, Austin	3	105.00
North Dakota State University	1	60.00
California Institute of Technology	4	155.00
University of Texas, Houston	1	100.00
University of Delaware	2	70.00
Weidlinger Associates	2	40.00
Princeton University	3	120.00
Brown University	5	205.00
Virginia Polytechnic Institute	3	40.00
University of Illinois, Urbana	2	233.13
University of Michigan, Ann Arbor	2	15.00
MPI	1	20.00
California State University Long Beach	1	40.00
Boston University	1	60.00
Dana-Farber Cancer Institute	1	25.00
Mayo Medical School	1	25.00
University of California, Santa Barbara	1	25.00
Mayo Foundation	1	25.00
University of California, San Diego	2	360.00
University of Maryland	1	51.90
Northwestern University	6	1,385.00
Vanderbilt University	1	10.00
University of Florida	2	185.00
Louisiana State University	3	70.00
Northeastern University	2	325.00
Ohio State University	4	37.00
Clark University	1	75.00
Texas Technical University	3	66.50
Toranto University	1	5.00
Drexel University	3	190.00
University of Rochester	1	10.00

NSF USER SUMMARY BY INSTITUTION FOR DECEMBER, 1986—Continued

Institution	Number of grants	Allocation
Yale University	1	20.00
University of Nebraska	3	150.00
University of Utah	1	75.00
University of California, Los Angeles	3	111.63
Pennsylvania State University	1	15.00
University of Michigan	2	42.00
Auburn University	1	25.00
University of Illinois	6	134.00
University of Washington	1	25.00
University of Iowa	1	15.00
University of Oklahoma	3	60.00
Rice University	3	80.12
Wright State University	1	5.00
Colorado State University	1	20.00
Rensselaer Polytechnical Institute	1	25.00
University of North Carolina, Chapel Hill	1	220.00
University of Kentucky	1	0.00
North Carolina State University	3	30.00
Georgia Institute of Technology	1	10.00
Illinois Institute of Technology	4	90.20
City College of New York	1	55.00
Syracuse University	1	35.00
Clemson University	1	10.00
University of Colorado, Boulder	1	10.00
University of Tulsa	1	40.00
University of Missouri	2	60.00
University of Miami	2	60.00
University of Pennsylvania	2	40.00
Southwest Research Institute	1	10.00
NCAR	1	200.00
Dartmouth College	1	10.00
NRAO	2	60.00
Minnesota State University, St. Cloud	1	3.00
National Science Foundation	1	5.00
Argonne National Lab	1	2.00
University of Houston	2	80.00
Clarkson University	1	5.00
Brigham Young University	1	10.00
Stanford University	1	10.00
University of California, Santa Cruz	1	10.00
Kent State University	1	10.00
University of Virginia	1	10.00
University of Southern California, Los Angeles	1	50.00
Washington, DC	0	0.00

Mr. SABO. Today we find ourselves in the situation where the federal government is cutting back access for its researchers to supercomputing facilities, just at the time interest and demand are escalating. While the national center model for providing this service made sense in 1984 it may no longer be appropriate in 1987.

Today there are 14 or 15 universities in the country which have supercomputers. NSF has funded supercomputers for only five academic centers, so there is obviously much more interest in this technology than we anticipated. The three Phase I centers have had NSF support for users, but they also acquired their supercomputers before NSF was involved.

Clearly these other institutions have entered this field with serious support from their state governments and other local sources. This indicates to me that there is a much greater commitment to the use of this technology in academia than we in Congress had anticipated. I believe that it would be truly unfortunate for NSF researchers if they are limited to only one third of the available resources for time and support in this work.

I also believe it is unfair and poor public policy to cut off all funding for Phase I centers which were started with local initiative and local funds. For instance, the University of Minnesota has 334 principal investigators, and 98 other universities using their center. All of these people will be displaced by current NSF policy. At the same time, I realize we have limited federal funds, and we need to support the program we started, at least until it can stand on its own.

For these reasons, I would like to propose to you a new approach for the federal support of advanced scientific computing programs. In order to honor our committment to Phase II centers, I would propose that we continue that program, as it has been started by NSF, through the duration of their present contracts. I believe most of them have five year contracts with NSF which will expire in 1990 or 1991.

At the same time, I would propose a certain portion, perhaps 15 percent of the total, continue to be available for NSF researchers to use Phase I centers. Under this proposal, NSF grantees will have access to eight different academic centers with their varying equipment and technical support staffs.

After the Phase II contracts have expired, I believe the NSF researchers should be able to purchase time at any facility which they consider appropriate to their needs. Obviously, there would be some limitations. Each institution would have to negotiate an acceptable fee schedule with NSF if it wanted to be approved. Also NSF would have to monitor the proposals of its researchers, so that the use is appropriate. (For instance, work that could be done on an IBM Personal Computer at low cost could not qualify for time on a Cray 2.)

I believe that this type of system will provide the maximum opportunity for our federally funded scientists to get the best computing support they can get. At the same time it will reward institutions which have serious local support, and provide the most innovative and comprehensive services to their users. It would still be necessary for NSF to have a supercomputing line item in its budget to ensure the optimal use of these funds. However this program would no longer be limited by decisions we and NSF made before we could begin to understand the potential for its use.

I thank you for your interest and would be happy to answer any questions.

[The prepared statement of Congressman Sabo follows:]

TESTIMONY OF CONGRESSMAN MARTIN OLAV SABO, BEFORE THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY, FEBRUARY 19, 1987

Mr. Chairman, members of the Committee, thank you for letting me appear before you today as you begin your hearings on the new authorization for the National Science Foundation (NSF). I served as a member of the HUD-Independent Agencies Subcommittee of Appropriations from 1979 until last May. As most of you know that is the appropriations subcommittee which deals directly with NSF's budget. During my 8 years on the that committee NSF was always one of my favorite agencies and I watched their programs with keen interest. However, the Foundation is now embarked on a path in one area which I think is mistaken. I would like to share my concerns with you.

The area which concerns me is the advanced scientific computing program. As the representative from the city which houses the corporate headquarters of this country's two supercomputer companies and one of the nation's leading supercomputer centers, I have been especially interested in this area. Since supercomputer technology is relatively new and rapidly evolving, it is important that we keep an open mind when looking at ways to use this technology. I believe NSF has set itself upon a very limited and limiting track in developing this program. And I believe the Foundation is making some very serious mistakes in this area.

History of Current Program

First I'd like to review some history with you so we can see where we have been to better assess where we should be going. In 1984 the NSF came before your committee and the Appropriations Committee and requested $20 million for an Advanced Scientific Computing initiative. Your committee reacted very positively to this proposal and in fact you responded with much more force and vision than the Foundation had shown. In your report on the authorization bill for the NSF in March 1984 you noted:

> The committee believes that strong initial support, as well as adequate continued funding, is essential for the development, implementation, and continuation of a program to provide the immediate and long-range needs for advanced computing services to the U.S. science and engineering research community. To insure that an effective program is developed, mechanisms should be established to facilitate the exchange and use of the latest computer developments among physicists, chemists, biologists, and many other researchers as well as computer scientists and electrical engineers.

Your committee requested that this initiative be carried as a line item in the Foundation's budget, and you tripled the program from $20 million to $60 million. Funding for the program was cut back in the appropriations process and finally ended up at $41.4 million. Obviously, the Congressional commitment to this program was very high. With subsequent appropriations of $46 million in 1986 and the House recommendation of $55 million for fiscal 1987 that commitment has been reiterated. (The 1987 level was reduced after the continuing resolution made a general cut of $73 million in NSF's budget. The NSF, however, took a much larger share of that cut out of supercomputer programs than they represent in the total NSF budget.)

In 1984 when the initiative was developed the Foundation was paying for access to available supercomputers for its researchers who needed supercomputing time. It did this by contracting for time with existing centers. Three were in academic situations—the University of Minnesota, Colorado State University and Purdue University. Three were in business settings—Boeing Computer Services, AT&T Bell Labs and Digital Productions. These six centers were called Phase I Resource centers. (In this discussion I will be referring to the academic centers only.)

In its initiative the Foundation proposed to develop a limited number of national supercomputer centers which would be designated as sites for use by NSF researchers and grantees. These sites were to be selected through a national competition. This competition was held and three academic sites were selected. Two were added later and these institutions—Princeton, San Diego, Illinois, Cornell and Pittsburgh—now comprise the Phase II centers for national advanced scientific computing.

In 1984 when your committee reviewed this initiative your report cited a study that said there was an immediate need for two large scale machines by science and engineering researchers. This report (the Borden/Curtis Report) further stated that as many as ten of these machines would be needed by researchers in the near future and that "at present many U.S. researchers are obliged to carry out their advanced scientific computations at foreign facilities."

Dr. Knapp, the Director of the NSF in 1984, reported to the appropriations subcommittee that:

> There was virtually unanimous agreement that important science is not being done because academic scientists and engineers have limited access to computational resources. . . .the needs for access to supercomputers in a variety of disciplines

are not well specified or understood. Yet it is likely that they will never be identified fully until scientists have much better access than at present.

We have since learned how farsighted his remarks were.

For the last three years NSF has funded the Phase I resource centers at a modest level as it has worked to build up its Phase II national centers program. NSF has always said it would stop funding Phase I centers when the Phase II centers were completed. In that same time we have seen a virtual explosion in the understanding of supercomputing possibilities. Scientists all over the country are just beginning to realize the incredible work they can do with this technology.

In 1986 NSF decided that it could no longer afford its Phase I centers even though the Phase II centers were not completed. It has summarily denied access to Phase I centers for its researchers. In fact the University of Minnesota was told on Wednesday February 11, 1987, that it had to close down all its NSF accounts by Friday February 13, 1987. Up until that point the University of Minnesota staff thought they were negotiating with NSF. I don't know all the details of their discussions but two days notice hardly seems fair—to either the center or its 334 NSF users.

Today we find ourselves in the situation where the federal government is cutting back access for its researchers to supercomputing facilities just at the time interest and demand are escalating. While the national center model for providing this service made sense in 1984, it may no longer be appropriate in 1987. Today there are 14 or 15 universities in the country which have supercomputers. NSF has funded supercomputers for only 5 academic centers, so there is obviously much more interest in this technology than we anticipated. (The three Phase I centers have had NSF support for users but they also acquired their supercomputers before NSF was involved.) Clearly these other institutions have entered this field with serious support from their state governments and other local sources. This indicates to me that there is a much greater commitment to the use of this technology in academia than we in Congress had anticipated.

I believe it would be truly unfortunate for NSF researchers if they are limited to only one-third of the available resources for time and support in this work. I also believe it is unfair and poor public policy to cut off all funding for Phase I centers which were started with local initiative and local funds. For instance, the University of Minnesota has 334 principal investigators and 98 other universities using their center. All of these people will be displaced by current NSF policy. At the same time, I realize we have limited federal funds and we need to support the program we started at least until it can stand on its own. For these reasons I would like to propose to you a new approach for the federal support of advanced scientific computing programs.

Proposal for a New Supercomputer Program

In order to honor our commitment to Phase II centers I would propose that we continue that program as it has been started by NSF through the duration of their present contracts (I believe most of them have five year contracts with NSF which will expire in 1990 or 1991). At the same time I would propose that a certain portion— perhaps 15% of the total—continue to be available for NSF researchers to use Phase I centers. Under this proposal NSF grantees will have access to eight different academic centers with their varying equipment and technical support staffs.

After the Phase II contracts have expired, I believe NSF researchers should be able to purchase time at any facility which they consider appropriate to their needs. Obviously, there would be some limitations. Each institution would have to negotiate an acceptable fee schedule with NSF if it wanted to be approved. Also NSF would have to monitor the proposals of its researchers so that the use is appropriate. (For instance work that could be done on an IBM personal computer at low cost could not qualify for time on a Cray 2.)

I believe that this type of system will provide the maximum opportunity for our federally funded scientists to get the best computing support they can get. At the same time, it will reward institutions which have serious local support and provide the most innovative and comprehensive services to their users.

It would still be necessary for NSF to have a supercomputing line item in its budget to ensure the optimal use of these funds. However, this program would no longer be limited by decisions we and NSF made before we could begin to understand the potential for its use.

I thank you for your interest and I would be happy to answer any questions.

Mr. **Walgren**. We appreciate your coming and raising that problem. It certainly seems hard to understand how we can be contracting the availability of supercomputers to the academic community at a time when we know that this is where a large part of the future interest in research is going. Your proposal certainly seems to have a lot positive in it. I would hope we could work our way forward so that those who were there when we needed them are not adversely affected by whatever the developments in this program would be. They certainly deserve a lot of consideration. They've just now suspended those contracts?

Mr. SABO. Th~~ank~~ you.

Mr. WALGREN. They have just now suspended those contracts?

Mr. SABO. Yes, they did. They notified the University on February 11 that they were being suspended effective February 13, which meant that there was a two-day notice for the University to make adjustments in their operational budget. I believe about 25 percent of operations in the Minnesota Computer Center are for NSF researchers.

It also meant that the scientists involved have to change where they are doing their supercomputing in the middle of whatever their research project is.

We're told, in terms of rationalization, that the reason for that is that word got around that NSF was going to cut off the eligibility for the Center for NSF use and that the researchers escalated their work trying to finish projects which hardly indicates lack of happiness by the researchers in the type of service and the quality of work they were getting.

So, now, wherever they are in their project, they have to switch their computing elsewhere to one of the designated NSF centers. That's the direction of the expanding availability of supercomputing facilities and NSF requiring scientists who have their grants to use a narrowing base of computing facilities.

Mr. WALGREN. The NSF researchers are not able to procure that service through any other facility other than a designated national center at that point?

Mr. SABO. Yes, a Phase II Center.

Mr. WALGREN. The other work that's being done on the computers, I gather, could continue, but certain users are mandated to leave at that point?

Mr. SABO. That's correct. Obviously if all of a sudden you lose about 25 percent of your operational base, you may still be able to continue but it makes it very difficult.

Mr. WALGREN. Well, we certainly want to express our interest in it and continue to follow it, particularly as this notice is so immediate that obviously there's going to be some further repercussions of that. I hope that those directly involved in that would come to us informally and directly as a Committee and keep us informed of what their circumstances are.

Mr. SABO. I expect you'll be hearing both from Colorado State and Purdue.

Mr. WALGREN. Yes. Are there other members who would like to raise points with Congressman Sabo?

Welcome our belated ranking minority member——

Mr. BOEHLERT. I knew our colleague was going to be here this morning and I made every effort to be here, but the train was late.

Mr. **Sabo**. The other place I'm supposed to be is over at the Transportation Subcommittee hearing for Mrs. Dole. I'll ask her about that.

Mr. **Boehlert**. Congressman, in a sense it will continually upgrade the equipment at the Phase II Centers so that these centers will always have access to state-of-the-art equipment. Would your proposal for the new separate computer program change that?

Mr. **Sabo**. Let me define it this way. The Phase I Centers were started on their own initiative without NSF help for the initial beginnings of those. Phase II Centers, the NSF is helping them not only build the center, but is giving them a monopoly on where NSF researchers do their work. Now there are new universities beyond Phase I and Phase II that are buying supercomputers.

My proposal would be to say that we continue to honor the contracts for Phase II Centers, which stand, I think, for five years. Use a certain portion of the funds for Phase I Centers, and then after 1990 make all of those new institutions eligible for supercomputing time. It would basically say that after five years you're buying operational support, not purchasing or buying equipment.

There's been a whole change in the nature of what's happening. When we started this program there were very few of the supercomputers available in academia. The whole nature of that field has changed. Today there are about 15 universities that have supercomputers, including the Phase I and Phase II Centers, and those who are in neither category. My understanding is that there may well be 20 by the end of the year.

So, that whole need for getting people to buy supercomputers, I think, is different than what it was when we started the program. On the other hand, I think we have to honor the contracts we made to Phase II Centers.

Mr. **Boehlert**. Do you think it's realistic the fact that with the idea of self-help that they would be able to upgrade their equipment?

Mr. **Sabo**. I would expect so. I think you have constant upgrading going on.

Mr. **Boehlert**. Would that in itself help?

Mr. **Sabo**. Yes.

Mr. **Boehlert**. Where is the money going to come from?

Mr. **Sabo**. From universities, from local support. As a matter of fact, one of the ironic things is that Minnesota was an applicant for a Phase II Center and it was turned down. One of the reasons they were told was that the Cray II might be too experimental, which was really ahead of the state of the art of where other centers were going. I think all the evidence has been that Minnesota was right and their peer review board was wrong, that this Cray II has worked very, very well.

But what I would suggest is to still continue to contract for supercomputing time from all of these centers. I suppose the issue you raise might be something we need to address in the future. But the trend at this point would seem to be that universities are moving in this area with or without NSF support for the actual purchase of machines.

Mr. **Boehlert**. I wish I was as optimistic as you are that they can do that without NSF help.

Mr. SABO. Well, the three Phase I Centers did it initially without NSF help. Minnesota's was the first in the country. Currently about seven universities have done it recently even though they are not Phase II Centers. My understanding is that another five may by the end of the year.

You know, who knows if we go beyond where we are today what kind of expense we're looking at. That might be different.

Mr. WALGREN. Are there other members who would like to raise——

Well, if not, we thank you very much for your concern and we look forward to talking to you about it individually.

Mr. SABO. I appreciate the opportunity of being here.

Mr. WALGREN. Thank you.

Well, with that let me call the first panel, as previously introduced, Mr. Homer Neal, LeRoy Lee, and Dr. Joan Straumanis, and before you begin, I would like to recognize Congressman Boehlert, the ranking minority member of this subcommittee, and one that we have enjoyed working with over the last number of years.

One of the nice things about the Congress is, it never stops, and we develop a little institutional memory, and a little institutional wisdom, and that's really represented in its greatest form by Congressman Boehlert. So, let me recognize you for an opening statement.

Mr. BOEHLERT. Thank you very much, Congressman Walgren. I've been looking forward to these authorization hearings because they come at a difficult point for the National Science Foundation. With its proposed "growth spurt" NSF is poised to enter adolescence. Thank you.

Without proper supervision, adolescents may start running with the wrong crowd, lose their sense of purpose, experiment excessively, succumb to "peer pressure," or neglect education. On the other hand, adolescence can be a time of great intellectual growth, new discovery, and responsible ventures into the working world.

At today's hearings we want to assure that NSF is paying enough attention to education. While NSF has proposed healthy increases for education, troubling questions have been raised about the adequacy of its support for elementary and secondary schools, and two and four year colleges. The Neal Report laid out a clear blueprint for undergraduate education, one that should be followed especially in a year the Foundation is seeking a 17 percent increase. NSF is the only agency charged specifically with improving science education at all levels. If the Foundation does not fulfill this vital responsibility, no other agency will take its place.

This does not mean, of course, that NSF can solve all educational woes, not even at the federal level. I question, for example, how the Administration can propose funding to improve colleges, while denying students the grants and loans they need to attend them. But this sort of "neutron bomb approach"—where we approve college facilities, and then empty them of students—is a subject for another day.

The President has recommended a generous increase for the National Science Foundation, and I applaud that proposal. The potential benefits to our nation from the research and education supported by NSF are incalculable. While this Subcommittee must play the stern parent, ensuring that NSF grows in a balanced way, we can also play the proud parent, being sure of NSF's striking record of accomplishment, and its glowing promise. Thank you, Mr. Chairman.

[The prepared opening statement of Mr. Boehlert follows:]

OPENING STATEMENT FOR THE HONORABLE SHERWOOD BOEHLERT (R-NY), NATIONAL SCIENCE FOUNDATION AUTHORIZATION HEARING, SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY, FEBRUARY 19, 1987

Mr. Chairman: I've been looking forward to these authorization hearings because they come at a pivotal point in the history of the National Science Foundation (NSF). With its proposed "growth spurt," NSF is poised to enter adolescence.

As we all know, adolescence is a period of both great promise and grave danger. Without proper supervision, adolescents may start running with the wrong crowd, lose their sense of purpose, experiment excessively, succumb to "peer pressure" or neglect education. On the other hand, adolescence can be a time of great intellectual growth, new discovery and responsible ventures into the "working world."

At today's hearing, we want to ensure that NSF is paying enough attention to education. While NSF has proposed healthy increases for education, troubling questions have been raised about the adequacy of its support for elementary and secondary schools, and two- and four-year colleges. The Neal report laid out a clear blueprint for undergraduate education—one that should be followed, especially in a year the Foundation is seeking a 17 percent increase.

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The President has recommended a generous increase for the National Science Foundation, and I applaud that proposal. The potential benefits to our nation from the research and education supported by NSF are incalculable.

While this Subcommittee must play the stern parent, ensuring that NSF grows in a balanced way; we can also play the proud parent, being sure of NSF's striking record of accomplishment and its glowing promise.

Thank you.

Mr. WALGREN. Thank you, Mr. Boehlert. With that, let's then turn to our panel, and ask you to present sequentially in the order that we introduced you. Your written statements will be made part of the record without objection. Feel free to expand on them, or underscore those points that you feel most important, and communicate them to this hearing in whatever way you would like to, most effectively. We also invite after the hearing any other thoughts that you might have. We will have a question period, but perhaps tomorrow or the next day, some things might strike you, and we would like you to give us some follow-up on your views, and your exchanges, and things that you feel perhaps should be developed further. So know that we have an open channel between us, and we are very interested in your views.

With that, we'll start first with Dr. Neal.

STATEMENT OF DR. HOMER A. NEAL, PROVOST, STATE UNIVERSITY OF NEW YORK AT STONY BROOK, STONY BROOK, NY; LEROY LEE, PRESIDENT, NATIONAL SCIENCE TEACHERS ASSOCIATION, ACCOMPANIED BY BILL ALDRIDGE, EXECUTIVE DIRECTOR OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION; AND DR. JOAN STRAUMANIS, THE ASSOCIATED COLLEGES OF THE MIDWEST, THE GREAT LAKES COLLEGES ASSOCIATION, CONNECTICUT COLLEGE, REED COLLEGE, AND ROLLINS COLLEGE

Dr. NEAL. Mr. Chairman, and members of the House Subcommittee on Science, Research and Technology, I am honored to have been requested to testify before you today on the issues fundamental to the advance of U.S. science and technology.

I have been informed by the Committee staff that you are especially interested in learning my views on the appropriateness of the National Science Foundation's response to the conditions in undergraduate science, engineering and mathematics education that were identified in the study I chaired for the National Science Board last year. I am pleased to share my assessment.

In addition, as a former member of the National Science Board, as the current chair of the National Science Foundation's Physics Advisory Committee, and as a member of the Foundation's science and engineering education advisory committee, I want to take this opportunity to comment on the critical importance of supporting the President's proposal for significantly increasing both the education and research components of the NSF budget.

Now a few words of background. In May of 1985, a committee of the National Science Board was formed to examine the state of U.S. undergraduate education in the sciences, engineering and mathematics. I was appointed as Chair of that committee, and the membership consisted of several members of the National Science Board, along with other members outside of the Board. Our findings were based on the testimony of many college presidents, senior academic administrators, faculty, professional society heads, representatives of industry and government, and a review of the current literature as well as the rich experiences of members of the committee. We made our report to the Board in March of 1986, so therefore, the report was indeed available to the Foundation in time for it to influence the development of the FY-88 budget submission to Congress.

In summary form, our findings included the observation of many troubling signs in undergraduate science and engineering education. The loss of interest by students in the core science, mathematics and engineering disciplines, frustrations on the part of the faculty who bear the responsibility for instruction, equipment which is in large measure obsolete, and a decrease in effort being devoted to curriculum development. All of these point to very serious problems in our future if they are not addressed.

The President's theme in the FY-88 budget message is that of competitiveness. Increased support of science, engineering and mathematics education in research must clearly be a primary component of any such initiative.

Now I will make a few comments on the response of the NSF to the report. By any account, it is clear that the NSF has made a genuine attempt to be responsive to the needs identified in our study. We had proposed an increase of $50 million dollars in FY-88, and the President's budget contained an increase of approximately $38 million. I wish the amount were more, but there can be no question that the Foundation is making a positive response.

The following provides an overview of the new programs the Foundation intends to implement. I should point out that during FY-87, the Foundation already instituted one new program, namely, Research Experiences for Undergraduates. This program is viewed both as a first step toward implementing the task committee's report, and as a base for a significantly expanded FY-88 program. The director and his staff are to be applauded for proceeding so quickly and implementing this important program.

The $9 million FY-87 research experiences program will provide about 2,000 undergraduates with opportunities for hands-on participation in active research. For FY-88, the NSF is proposing to increase its activities at the undergraduate level from about $30 million to about $68 million. This includes expansion of the Research Experiences for Undergraduates program, the establishment of a series of faculty research experience sites for undergraduate faculty, short courses and seminars for faculty, instructional instrumentation support, a restructuring of the engineering curricula, revision of the introductory calculus sequence, and a comprehensive improvement program to simultaneously improve laboratory instructional equipment and teaching materials, and provide for faculty and student development.

Now the preliminary material, made available regarding the planned desegregation of the FY-88 NSF funds, permit certain analyses to be made. The major differences that one observes between the recommendations of our task committee, and the FY-88 NSF budget requests are confined to two categories. One is that the NSF has put even more funds into the support of undergraduate faculty and student research than the committee recommended. The other is that only roughly half of the funds recommended by the committee for instrumentation and laboratory development, was actually requested by the Foundation.

Both of these programs are critical ones, but I do question this differentiation. Because of the strong evidence that a highly leveraged instrumentation program is badly needed, I have suggested that a careful internal review be made involving the Science and Engineering Education Directorate, to assess what is the proper balance between these two program activities.

Next, I would like to turn briefly to the question of balance between research and education. This is one of the more difficult questions that must be faced by the Foundation, by the Science Board, and by Congress. Namely, what is the appropriate percentage of total NSF resources that should be devoted in support of education.

Primary guidance on this point should of course come from the Foundation itself, following an ongoing careful analysis of overall priorities. There is a broad sense of unease about the significant increase in the Foundation's research budget over the past decade mirrored against the decrease in support for undergraduate education programs over this period. This implies a collective lack of understanding of the importance of the NSF's role in education.

It is very encouraging to note that the initiatives planned by the Foundation in undergraduate science education in FY-88, as well as projections over the next several years seem to indicate that a marked reversal is occurring. We do have a very long distance to go. NSF spends approximately $1.6 billion on research, and less than $0.06 billion on programs explicitly designed to enhance the undergraduate education of our future scientists, engineers and mathematicians.

Of course in the abstract, those two numbers mean nothing, but numerous analyses have shown that there are serious problems with both. $1.6 billion for basic research is absolutely too small for the primary agency charged with enhancing federal fundamental research across all scientific, engineering, and mathematic disciplines, in the world's leading technological nation. Certain large companies spend sums of this magnitude on research. The amount we spend as a nation for high quality, fundamental research should be much, much larger. Regarding the $0.06 billion spent on undergraduate education, we should be ashamed of ourselves.

Discovery made by a single motivated undergraduate student, after successfully completing his or her work, can generate returns to the country, at a level that is far in excess of the $60 million dollars.

I will not take the next step in my on-the-record remarks to discuss what the relative allocation between research and education should be. Especially since the optimum division also depends on the total. And this in turn depends on just what we want our country to be in the future.

It should be clear to all, even to those who view the responsibility for undergraduate education in a very restricted sense, as belonging almost exclusively to the states. But the same scholarly, spearheading activities that justify significant federal involvement in frontier research in the various disciplines, also justity an identical role in that very challenging task of imparting knowledge to future generations, in an environment where the growth of essential knowledge is virtually exploding.

Another issue that our report addressed was that of the organization of the NSF to deal with undergraduate activities. Once again, in large measure, the manner in which an agency chooses to go about achieving goals that have been agreed to, should be decided by the director and senior staff of the agency. I believe this should be the overriding consideration in the case of how the NSF should organize itself to mount an effective long term presence in undergraduate education. However, since program coordination was one of the issues raised in our report, I will make the following observations.

There is a need to more clearly define the role of the Directorate of Science and Engineering Education. Either it should have, or should not have, a primary role in coordinating the Foundation's efforts in undergraduate education. Leaving this question open creates unnecessary confusion. Confusion derives from the fact that it is virtually inconceivable that any other unit should have this coordinating responsibility, particularly given the recent creation of this directorate by Congress to have broad responsibility for science, engineering and mathematics education.

There are many suggestions regarding which structure should be used. These suggestions arise not necessarily because individuals wish to suggest an organization for the NSF just for the sake of engaging in micromanagement exercises, but because the effectiveness with which broad policy goals can be achieved, can depend critically on how the NSF is internally organized. Indeed, the internal organization dictates the external interfaces. There can be no doubt that whatever the organization, there must be strong participation of the research directorates. That is not the issue. More to the point, is whether a Dean, a Provost, a President, a faculty member, for example, should have to talk to a dozen division heads or coordinating committee members to explore novel initiatives, rather than to a single Foundation Officer of stature, who can mobilize the entire Foundation to take action when appropriate.

My recommendation on this point is that the Directorate of Science and Engineering Education be the Office assigned this responsibility. If that directorate requires more resources to accomplish this task, then those resources should be provided.

On the broader and much discussed question of which federal agency should have responsibility for science education, I believe that there is no doubt that it should be the National Science Foundation. It is only that agency that has the extensive network of connections to academic scientists and engineers necessary for the effective implementation and management of novel science education activities. Moreover, the recent NSF initiatives in the undergraduate area and the anticipated future budget growth for research and education represent additional reasons to expect that these programs will be properly nurtured at the NSF in the future.

In view of the time, I wish to go directly to the question of the need for increased support for U.S. science and technology. It's important for you to be aware that I come to this issue of the support for undergraduate education from as remote a viewpoint as anyone could imagine. I've never viewed myself as a faculty member with either special interest in, or aptitude for undergraduate education, though I must admit I was very pleased when I was given the Physics Department's Outstanding Teacher Award early in my career.

As a chief academic officer for five years, up until this past summer at the State University of New York at Stony Brook, I had the heavy responsibility of overseeing both undergraduate instruction and graduate education and research. Even with this background, however, I entered the work of our task committee with an open mind, and was even willing to be convinced that the NSF was spending too much money on its science education activities. I'm firmly convinced now that the opposite is true. I'm also aware from my years of service on the National Science Board that significant changes in an institution such as the NSF, must be made carefully, and with adequate planning and preparation. Indeed, it is this very point that causes me to interpret the major shift that has occurred this year in the Foundation's allocation for undergraduate activities as being positive and responsive, especially since I am informed that undergraduate education is also to be one of the priority areas in the process which is to lead to a doubling of the Foundation's budget over the next five years.

Education and research are and should be integrally coupled. They're just time shifted aspects of the same entity. The Nobel laureate often is educated, positively that is, through interactions with his or her undergraduate assistants, and graduate students, even as these students traverse the complicated paths to becoming our future Nobelists. For this reason, I want to make sure that I do not deliver testimony that treats only the subject of education without also referring to conditions in research as well.

As a physicist, as Chair of the National Science Foundation's Advisory Committee on Physics, I am well aware of the precarious nature of funding for research in this discipline, and how fundamental our discipline is to essentially all others. Advances in most applied areas in the future will depend on our basic research discoveries today. I'm also aware of compelling conditions for additional support in other disciplines. Indeed, my comments are not intended to be special pleading just for physics. There are amazing and rare opportunities in many areas of science, engineering and mathematics that the NSF is having to forego for lack of research funds. Something must be done to correct the situation. Investment in the work of talented researchers is one that our country must realize will yield far greater returns than almost any other investment, even in times of limited resources.

I am of course pleased by the initiatives being taken to boost our capabilities in engineering and computer science, and by the President's decision to proceed with the construction of the Superconducting Super Collider. These are all steps that will help to ensure the continued vitality of our scientific and industrial communities in the decades to come.

These steps, however, must be accompanied by an extraordinary commitment to do an exceptional job in educating our students at all levels, and in nurturing the development of the fundamental sciences across all areas. For collectively they form the human resource and axiomatic base upon which all of our activities ultimately must rest.

Thank you again, Mr. Chairman.

[The prepared statement of Dr. Homer A. Neal follows:]

TESTIMONY PRESENTED TO THE HOUSE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

by

Homer A. Neal

Leading Professor of Physics

State University of New York at Stony Brook

Stony Brook, New York 11794

February 19, 1987

INTRODUCTION:

Mr. Chairman and members of the House Subcommittee on Science, Research and Technology: I am honored to have been requested to testify before you today on issues fundamental to the advance of science and technology in the United States.

I have been informed by the Committee staff that you are especially interested in learning of my views on the appropriateness of the National Science Foundation response to the conditions in undergraduate science, engineering and mathematics education identified in the study I chaired for the National Science Board last year. I am pleased to share my assessment.

In addition, as a former member of the National Science Board, as the current Chair of the National Science Foundation's Physics Advisory Committee and as a member of the Foundation's Science and Engineering Education Advisory Committee, I want to take this opportunity to comment on the critical importance of supporting the President's proposal for significantly increasing both the education and research components of the NSF budget.

BACKGROUND:

In May, 1985 a Committee of the National Science Board was appointed to examine the state of U.S. undergraduate education in the sciences, engineering, and mathematics. I was appointed as Chair of this committee, and the membership consisted of several other members of the Board as well as other individuals outside the Board. Our findings were based on the testimony of many college presidents, senior academic administrators, faculty, professional society heads, representatives of industry and government, and a review of current literature, as well as the rich experiences of members of the Committee. We made our report to the Board in March, 1986. The report was thus available to the Foundation in time for it to influence the development of the FY1988 budget submission to Congress.

Our findings included the observation of many troubling signs of deterioration: a loss of interest by students in the core science, mathematics and engineering disciplines; frustrations on the part of the faculty who bear the responsibility for instruction; equipment which is in large measure obsolete; and a decrease in effort being devoted to curriculum development -- all of which point to serious problems in our future.

The President's theme in his FY88 budget message is that of competitiveness. The increased support of science, engineering, and mathematics education and research must clearly be a primary component of any such initiative.

THE RESPONSE OF THE NSF TO THE CONDITIONS IDENTIFIED IN THE REPORT OF THE NATIONAL SCIENCE BOARD:

By any account, it is clear that the NSF has made a genuine attempt to be responsive to the needs identified in our study. We had proposed an increase of $50 million in FY88, and the President's budget contains an increase of approximately $38 million. I wish the amount were more, but there can be no question that the Foundation is making a positive response. The following provides an overview of the new programs the Foundation intends to implement.

During FY1987, the NSF already instituted one new program, Research Experiences for Undergraduates (REU). This program is viewed both as a first step toward implementing the NSB Task Committee's Report, and as a base for a significantly expanded FY1988 undergraduate program. The Director and his staff are to be applauded for proceeding so quickly in implementing this important program.

The 9$ million FY 1987 REU program will provide about 2,000 undergraduates with opportunities for hands-on participation in active research. The program will make two types of awards, averaging in size about $4,000 per student. These include grants to initiate and support undergraduate research participation sites; and supplements to ongoing NSF research awards to provide research training experiences.

For FY 1988 the NSF is proposing to increase its activities at the undergraduate level from about $30 million to about $68 million. This includes expansion of the Research Experiences for Undergraduates (REU) program, the establishment of a series of faculty research experience sites for undergraduate faculty, similar in principal to, and sometimes combined with, REU Sites for students; support for faculty workshops, short courses, and seminars, to inform undergraduate faculty about forefront research results, and to share information about effective instruction; instructional instrumentation support; evaluation and restructuring of engineering curricula; revision of the introductory calculus sequence; and a comprehensive improvement program to simultaneously improve laboratory instructional equipment and teaching materials, and provide for faculty and student development.

The Task Committee recommended the following distribution of incremental funds for FY88:

Program Title:	Task Committee Incremental FY88 Recom. (in M$ above FY87 Actual)
Instrumentation/Lab Dev	+20
Faculty enhancement	+10
Undergraduate research	+8
Course and Curriculum	+7
Minority Institutions	+5

	+50

The preliminary material regarding the planned disaggregation of FY88 NSF funds permits certain analyses to be made. The major differences that one observes between the recommendations of the Task Committee and the FY88 NSF Budget Request are confined to two categories. One is that the NSF has put even more funds into the support of undergraduate faculty and student research than the committee recommended (approximately $18M vs. $9M). The other is that only roughly half of the funds recommended by the Committee for instrumentation and laboratory development was actually requested by the Foundation ($11.5M vs. $20M). Both of these programs are critical ones, but I question this differentiation. Because of the strong evidence that a highly leveraged instrumentation program is badly needed, I have suggested that a careful internal review be made, involving the Science and Engineering Education Directorate, to assess what is the proper balance between these two program activities.

RESEARCH AND EDUCATION: THE QUESTION OF BALANCE

One of the most difficult questions that must be faced by the Foundation, the National Science Board and Congress is whether the percent of total NSF resources devoted to the support of education is appropriate. Primary guidance on this point should, of course, come from the Foundation itself, following an ongoing careful analysis of overall priorities. There is broad unease, however, that the significant increase in the Foundation's research budget over the past decade - mirrored against the decrease in support for undergraduate education programs over this period - implies a collective lack of understanding of the importance of the NSF's role in education. It is very encouraging to note that the initiatives planned by the Foundation in undergraduate science education in FY88, as well as projections over the next several years, seem to indicate a marked reversal in this trend.

But we do indeed have some distance to go. The NSF spends approximately $1.6 billion on research and less than $0.06 billion on programs explicitly designed to enhance the undergraduate education of our future scientists, engineers and mathematicians. Of course, these two numbers mean absolutely nothing in the abstract. Numerous analyses have, however, shown that there are problems with both. The $1.6 billion for basic research is absolutely too small for the primary agency charged with enhancing fundamental research across all scientific, engineering and mathematics disciplines in the world's leading technological nation. Certain large U.S. companies spend sums of this magnitude for research. The amount we spend as a nation for high quality, fundamental research should be much, much larger. Regarding the $0.06 billion spent on undergraduate education -- we should be ashamed of ourselves. The discovery made by a single motivated student can generate returns to the country at a level that is far in excess of this!

I will not take the next step in my on-the-record remarks to discuss just what the relative allocation between research and education should be, especially since the optimum division also depends on the total, and this in turn depends on just what we want our country to be in the future. But, it should be clear to all, even to those that view the responsibility for undergraduate education in a very restricted sense as belonging almost exclusively to the states, that the same scholarly, spearheading activities that justify significant federal involvement in frontier research in the various disciplines also justify an identical role in that very challenging task of imparting knowledge to our future generations -- in an environment where the growth of essential knowledge is virtually exploding.

ORGANIZATION OF THE NSF UNDERGRADUATE ACTIVITIES:

In large measure, the manner in which an agency chooses to go about achieving goals that have been delineated and agreed to must be decided by the Director and senior staff of that agency. I believe this should be the overriding consideration in the case of how the NSF should organize itself to mount an effective long term presence in undergraduate education. However, since program coordination was one of the issues raised in our report, I will make the following observations.

There is a need to more clearly define the role of the Directorate of Science and Engineering Education. Either it should have or should not have a primary rôle in coordinating the Foundation's efforts in undergraduate education. Leaving this question open creates unnecessary confusion. This confusion derives from the fact that it is virtually inconceivable that any other unit should have this coordinating responsibility, particularly given the recent creation of this Directorate by the Congress to have broad responsibility for science, engineering, and mathematics education.

The concept of utilizing intra-directorate coordinating groups for ongoing, major activities such as undergraduate education would not seem to be an appropriate long term mechanism. Such arrangements may be fine for temporary, task oriented activities -- but not for central, long term endeavors. Thus, my recommendation to the Foundation is to move as quickly as possible to assign visible responsibility for the coordination for undergraduate activities.

It is not unreasonable to expect that the Foundation's support for undergraduate science, engineering and mathematics education will exceed two hundred million dollars in the near future. Such a budget should be overseen by a clearly designated office, even if the actual expenditures are made through several independent channels within the Foundation.

There are many suggestions regarding which structure should be used. These suggestions arise not because individuals wish to suggest an organization of the NSF just for the sake of engaging in micro-management exercises, but because the effectiveness with which broad policy goals can be achieved can depend critically on how the NSF is internally organized. Indeed, the internal organization dictates the external interfaces. There can be no doubt that whatever the organization, there must be strong participation of the research directorates -- that is not the issue. More to the point is whether a Dean, a Provost, a President, a faculty member, for example, should have to talk to a dozen Division Heads or coordinating committee members to explore novel initiatives, rather than to a single Foundation Officer of stature who can mobilize the entire Foundation to take action when appropriate.

My recommendation on this point is that the Directorate of Science and Engineering Education be the Office assigned this responsibility. If that Directorate is judged not to have the appropriate resources to accomplish this task, then they should be added immediately.

On the broader and much discussed question of which federal agency should have responsibility for science education, I believe there is no doubt that it should be the National Science Foundation. It is only that agency that has the extensive network of connections to academic scientists and engineers necessary for the effective implementation and management of novel science education activities. Moreover, the recent NSF initiatives in the undergraduate area, and the anticipated future budget growth for research and education, represent additional reasons to expect that these programs will be properly nurtured at the NSF in the future.

COMPETITIVENESS:

I was very pleased to note that the President's budget message both stressed the need for our country to remain technologically competitive and that it acknowledged the role of education in achieving this goal.

It is important that those who interpret this message recognize its full ramifications, since the term competitiveness often fails to convey the full impact of its significance when applied to the preservation of a nation's economic health. It is easy to think of competitiveness as that very positive spirit associated with our favored sports activities, where it is nice to win, but if one loses, one only has to look forward to the next season.

The loss of technological competitiveness often means that we can not manufacture the things we need in this country and that they must be purchased elsewhere, leading to the loss of U.S. jobs, a weakening of our ability to care for our poor, and for that matter, to properly fund our educational system. Indeed, we are aware of the fact that many of the very high technology components required for our national defense must be purchased from other countries -- because they are not available in this country.

To pick a specific example of a primary consumer item, the loss of our lead in advanced microprocessors is responsible for a trade deficit of billions of dollars. This translates into a loss of hundreds of thousands of jobs, with an associated cost in human terms, and in municipal, state, and federal revenues foregone. Being second or third is costly. While dominating in each and every endeavor may not be possible or even reasonable, to lose out to other nations just because we do not make rational investments in our human resources and inventive activities just does not make sense.

UNTAPPED HUMAN RESOURCES:

The term "minority" is often used to refer to groups within our population from Afro-American, Latino and American Indian backgrounds, among others. Demographics indicate that these ethnic groups are rapidly moving from being a minority component of our population toward becoming the majority. Yet we find the fraction of members of these groups electing to pursue studies in the scientific and technical fields is extraordinarily small. This observation is reflective of past social exclusion and points to difficulties for our country in the years ahead, when we will have a lack of qualified technical personnel to fill the critical jobs in many disciplines. It is not just a human issue at stake, but a national manpower dilemma as well.

Efforts to encourage more minorities to pursue studies in science, engineering, and mathematics must be stressed. To this end, there are vital roles to be played by all types of institutions, ranging from the large research universities to the historically black colleges which, given the meager resources they have had at their disposal, have done a remarkable job over the decades, but who will need additional focused assistance in the future. In my view, there remains a strong and justifiable role for the federal government in this area.

THE NEED FOR INCREASED SUPPORT OF U.S. SCIENCE AND TECHNOLOGY:

It is important for you to be aware that I come to this issue of the support for undergraduate education from as remote a viewpoint as anyone could imagine. I have never viewed myself as a faculty member with either special interest in, or aptitude for, undergraduate education (though, I must admit that I was very touched when I was given the Physics Department's Outstanding Teacher Award early in my career). As the chief academic officer for five years at my current university I, of course, had the heavy responsibility of overseeing both undergraduate instruction and graduate education and research. Even with this background, I entered the work of our Task Committee with an open mind -- and was even willing to be convinced that the NSF was spending too much money on its science education activities. I am firmly convinced now that the opposite is true. But I am also aware, from my six years of service on the National Science Board, that significant changes in complex institutions such as the NSF must be made carefully and with adequate planning and preparation. Indeed, it is this very point that causes me to interpret the major shift that has occurred this year in the Foundation's allocation for undergraduate activities as being very positive and responsive -- especially since undergraduate education is also to be one of the priority areas in the process which is to lead to a doubling of the Foundation's budget over the next 5 years.

Education and research are, and should be, intricately coupled. They are just time-shifted aspects of the same entity. The Nobel Laureate often is "educated" (positively, that is, and in original ways) through interactions with his or her undergraduate assistants and graduate students, even as these students traverse the complicated paths to becoming our future Nobelists. For this reason, I want to make sure that I do not deliver testimony that treats only the subject of education, without referring to conditions in research as well.

Perhaps my testimony would be more credible if I were to make a strong statement that "A" is important and should be boosted even at the expense of "B". Unfortunately, such an analysis must occur in another setting, on another subject, on another day. My argument today is that both research and education are important and both are greatly undersupported in our current budgets.

As a physicist, and as Chair of the National Science Foundation's Advisory Committee on Physics, I am well aware of the precarious nature of funding for research in this discipline, and how fundamental our discipline is to essentially all others. Advances in most applied areas in the future will depend on our basic research discoveries today. I am also aware of compelling conditions for additional support in the other disciplines. Indeed, my comments are not intended to be a special pleading just for physics. There are amazing and rare opportunities in many areas of science, engineering and mathematics that the NSF is having to forego for lack of research funds. Something must be done to correct this situation. The investment in the work of talented researchers is one that our country must realize will yield far greater returns than almost any other investment, even in times of limited resources.

I am, of course, pleased by the initiatives being taken to boost our capabilities in engineering and computer sciences and by the President's decision to proceed with the construction of the Superconducting Super Collider. These are all steps that will help to insure the continued vitality of our scientific and industrial communities in the decades to come. These steps, however, must be accompanied by an extraordinary commitment to do an exceptional job in educating our students at all levels and in nurturing the development of the fundamental sciences across all areas, for collectively they form the human resource and axiomatic base upon which all of our activities ultimately must rest.

Thank you again, Mr. Chairman. I hope that my remarks will be of use to the Committee in its deliberations.

The Emerging Crisis in Undergraduate Science, Engineering, and Mathematics Education

by

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Introduction

There are several paradoxes evident within our educational system. We acknowledge that our children are our most precious resources. We acknowledge our sacred responsibility to impart to our children knowledge of our world and the wonders of human history, and to arm them with the intellectual tools they will require for productive life. Nevertheless, we commit them to a long institutional sentence, and then pay the valiant wardens entrusted with this awesome responsibility at a rate that is terribly close to the poverty level.

We acknowledge that much of the future economic, social and military integrity of our country depends on our ability to train a technologically advanced workforce, yet we sustain a system that routinely deflects talented students from science, engineering, and mathematics studies. One quickly senses that there are problems.

When one encounters a problem that is characterized largely by visible input and output quantities, it is only natural that primary emphasis is placed on conditions at the input and output ends of the so-called pipeline. Thus, in science, engineering, and mathematics education, there is much discussion about the experience of students in the early years of grade school, as well as discussions of supply and demand at the postgraduate end. Indeed, we can clearly infer that we have very serious problems at the elementary school level. That we are calling upon teachers who have had very little training in science to impart the joy of science to our children, that we have made the teaching profession unattractive to many, that our children are being turned off of mathematics at a very early age — these are all indications of severe problems at the input end. At the output end, it is clear that something is wrong as we see our balance of trade slip so dramatically, even in the technological areas, as we see our innovativeness decline, and as we see two thousand engineering faculty positions at colleges and universities go unfilled. Such symptoms clearly highlight problems at both the input and output. These are serious problems and, indeed, we as a nation are beginning to respond. But there are also problems in the middle of the pipeline, in the undergraduate section, and these will not necessarily disappear just because repair work is done at the input and output ends.

To stick with the plumbing metaphor a little longer, undergraduate science, engineering and mathematics education is coming apart at the seams. Some would suggest that this is an alarmist view -- an overstatement of the problem. Others of us humbly submit that it is indeed time for the alarm to be sounded.

When plumbing comes apart at the seams, there are many possible contributing causes. One is a rupture caused by some catastrophic event, such as a hard freeze. Another possibility is just a fairly slow deterioration of the system caused by corrosion, deposits, or use beyond design capacity. The latter may be the proper way to characterize what has happened over the last two decades to undergraduate science and engineering education. A university here and there eliminated laboratory courses as a cost savings step. A federal agency here and there cut out all or essentially all of its support for innovations in undergraduate curriculum. Fewer and fewer faculty members chose to devote their energies to curriculum improvement projects, perhaps inferring -- correctly or incorrectly -- that their institution is according lower priorities to such undertakings now than in the past. Certain universities devoted less and less of their budgets to the maintenance of their undergraduate science and engineering laboratories, while resolutely promising themselves to address the problems "next year". Slowly, then, our undergraduate programs have suffered. We should not await the impact of another Sputnik before recognizing the decline in quality of our undergraduate programs and taking steps to redress these problems.

Background of National Science Board Study

In May 1985 a task committee was established by the National Science Board (NSB) to study the health of undergraduate science, engineering, and mathematics education and I was assigned the responsibility of being its Chair. Other members of the Committee were Dr. Jay V. Beck (member of the NSB, Professor Emeritus of Microbiology, Brigham Young University), Dr. Thomas B. Day (member of the NSB, President, San Diego State University), Dr. Norman Rasmussen (member, National Science Board, Professor of Nuclear Engineering, MIT), Dr. James L. Powell (President, Franklin and Marshall College), Dr. Rita R. Colwell (member, NSB, Vice President for Academic Affairs, Univ. of Maryland), Dr. James J. Duderstadt (member, NSB, Dean of Engineering, University of Michigan), Mr. Lester G. Paldy (Dean, Center for Continuing Education, State University of New York at Stony Brook), and Dr. Robert F. Watson (Head, Office of College Science Instrumentation, National Science Foundation).

The Committee met several times during the period May, 1985 to March, 1986. Four of these meetings were full-day hearings held in Washington where many educational leaders, professional society heads, government representatives and industrial leaders delivered testimony on their perceptions of the state of undergraduate education in science, engineering and mathematics in the United States. This testimony, reviews of previous studies, and the personal knowledge of members of the committee and Foundation staff, formed the basis for the recommendations issued by the Committee in March, 1986.

Importance of a Technically Advanced Society

Undergraduate education plays an enormously important role in sustaining the economic well-being of our country. For example, the baccalaureate degree is regarded as the terminal degree in most engineering disciplines. The quality of the graduates who enter industry each year, and who form the backbone for the technical and economic base for our country, is determined in large measure by how good a job is done by our undergraduate institutions.

A recent report on the foreign balance-of-trade in high-technology goods shows that in the past several years the decline in our "exports minus imports" amounts to many billions of dollars. Indeed, it appears that 1986 will become the first year that the U.S. will have an absolute trade deficit in the high-tech area. Just last year we had a trade surplus in the high-tech markets of over $4 billion. This decline represents a loss of tens upon tens of thousands of jobs to other countries. In turn, this loss of jobs has an impact on many different components of our society, including our ability to care for the poor or to fund research on critical national problems, to mention just two examples.

As pointed out in our report " The most striking and pervasive change of the 1980's - one that is fundamental and irreversible - is the shift to a global economy. The only way that we can continue to stay ahead of other countries is to keep new ideas flowing through research; to have the best technically trained, most inventive and adaptable workforce of any nation; and to have a citizenry able to make intelligent judgments about technically-based issues. Thus, the deterioration of collegiate science, mathematics and engineering education is a grave long-term threat to the Nation's scientific and technical capacity, its industrial and economic competitiveness, and the strength of its national defense."

Expenditures for Undergraduate Education

According to Fall 1984 statistics, there were 10,700,000 undergraduates attending some 3,300 United States institutions of higher learning. Annual expenditures in support of these programs amounted to $42 billion. Of this amount, it is estimated that expenditures for undergraduate science and engineering education were at least $10 billion.

We observed that state funding for higher education increased by very significant amounts over the past ten years — but not in proportion to the the enrollments nor in sufficient amount to repair the ravages of previous double-digit inflation. Private support for higher education has also grown over this period, but most industries have focused their support on graduate education and research that is closely related to their corporate interests, with relatively little attention focused upon the undergraduate base. In summary, resources for undergraduate science and engineering education have fallen steadily behind needs.

Whose Responsibility is Undergraduate Education

While bodies like the National Science Board can point with concern to trends in undergraduate science, engineering, and mathematics education and urge corrective action, it must be emphasized that responsibility for the academic health of undergraduate education resides primarily in the nation's colleges and universities and their governing bodies. Responsibility for the financial health of the educational institutions lies primarily with states, municipalities, and the host of supporters of private education. We should note that the total research and education budget of the National Science Foundation is approximately $1.5 billion. If this entire amount were spent, for example, on equipment for undergraduate engineering education alone, it would not be enough. Indeed, a study conducted by the National Research Council suggests that the instrumentation needs in undergraduate engineering alone exceeds $2 billion. This demonstrates the importance of involving a broad participation of all sectors in seeking, finding and funding solutions.

What are the Problems?

Some are specific to particular disciplines, and some are generic. Before reviewing the special issues pertinent to certain disciplines, it would be illuminating to review excerpts from the following article published in Nature in November, 1985:

> " There is mounting and disturbing evidence that the quality of teaching in both public and private universities is declining. Faculty are aging and are not being replaced at sufficient rate, especially in engineering. Laboratory instrumentation is, despite corporate munificence, seriously out-of-date, particularly in institutions not famed as research establishments. And increasing teaching loads all to often force universities and colleges to rely on the teaching of undergraduates by new graduates, for many of whom English is not a first language.
>
> Quantity is another and a daunting aspect of the problem. The proportion of young people in the United States going on to higher education in science and engineering is only a half of what it is in Japan, while there is mounting evidence that demand is being constrained both by the high cost of higher education and the continuing poverty of high-school

> education at all but the excellent institutions. Can the United States continue to be astonished at the imbalance of its trade with Japan?...
>
> The result of this neglect is that university teaching has come to seem a chore to faculty members at many institutions, not an activity vital to the function of an institution.....
>
> By any analysis, the strength of the United States rests on its scientific and technical workforce, as do all of its hopes for the future. There is no known alternative to diligent study and excellent teachers. Americans should not need to be told that."

There are numerous parameters that one can examine to get a sense of how well we are doing in training our future generations. Some of these do not paint a very attractive picture:

- there is a decline in the number of freshmen indicating an interest in pursuing studies in the sciences and engineering
- there has been a decline in the percentage enrollment in core science courses in grades 9-12
- we are facing a significant demographic decline of 18 year-olds and unless other factors are changed many science and engineering fields will likely suffer workforce shortages
- the supply of new science and mathematics teachers at the high school level has been dropping over the past 15 years
- the performance of United States 12th grade students in algebra and calculus is comparable to that of the international average, and significantly less than that of, for example, Japan
- there has been a decline in the science achievement scores of our 17 year olds
- federal support for explicit undergraduate science and engineering education programs has declined sharply over the past decade
- there has been a dramatic decline in the U.S. balance of trade in high-technology products
- there has been a steady decline in the number of U.S. patents to U.S. inventors, and a growing number to foreign inventors

Other, less easily quantified, information also gives rise to heightened concern. This includes:

- evidence that the great majority of undergraduate students are not receiving the scientific, technical and mathematical training they need
- evidence that texts and other instructional materials are being utilized even though they are seriously outdated
- evidence that few incentives exist to encourage faculty to remain current, vital, and dynamic

- evidence that limited attention is being paid to curriculum development

Special Issues Pertinent to Engineering

Society is becoming increasingly dependent on the availability of talented engineers. The health of the nation's engineering schools is a central factor determining our economic and military security and our quality of life. As a result of massive growth in the number of students who have responded to the increasing need for engineers, our universities have experienced overloading of facilities and personnel during a period of austerity, leading to a decline in the quality of education provided.

There is right now a serious shortage of faculty in most branches of engineering and this situation is expected to get worse in certain branches in the years ahead. The situation is due partly to the attractiveness of entry-level positions in industry. Positions available to new B.S. recipients offer salaries sufficiently attractive to convince many that advanced training to the Master's Degree and beyond is neither financially justifiable nor required for participating in exciting projects in industry. The result is a paucity of engineers available for academic careers. One estimate is that the production of potential faculty members is only half the national need. Roughly 1,500 (8.5%) of the nation's budgeted engineering faculty positions remain vacant. If resources were deployed to cope with enrollment growth during the past decade, 6,700 faculty positions would have to be filled.

Recent NSF surveys have estimated that only 18% of the equipment used in engineering instructional laboratories is state-of-the art. As indicated above, the accumulated deficiency in needed laboratory equipment now exceeds $2 billion.

There was wide agreement that more attention should be paid to curriculum development in engineering education. This is at least partly due to an overloaded and aging faculty, as well as the absence of external programs aimed at stimulating curriculum innovation and implementation.

Issues Pertinent to Mathematics Education

In the first two years of college, a typical undergraduate science or engineering student takes as many courses in mathematics as in the chosen major. For students preparing for a research career in science or engineering, the total number of courses in mathematics taken over the four years may exceed the number of courses in the major. Successful efforts to improve the undergraduate curriculum in mathematics will have immediate impact not only on mathematics but also on instruction in all the sciences and engineering.

Even for the "general" student, one or more courses in mathematics are required or elected. Thus, successful efforts to improve mathematics instruction can have a significant impact on the level of scientific literacy of the nation.

The specter of a major shortage of qualified college mathematics faculty looms on the horizon. A major decrease in the rate of production of Ph.Ds in mathematics is occurring simultaneously with an increase in the number of non-academic jobs that are available for mathematicians and an almost explosive rise in registrations in relatively elementary mathematics courses in colleges and universities. This increase derives from larger enrollments in engineering and some science curricula, and the steady rise over the past twenty years in the amount of instruction that must be done to remedy deficiencies in the mathematical preparation of students in the secondary schools.

The pace of necessary changes in the undergraduate mathematics curriculum will be too slow unless substantial support comes from sources external to colleges and universities. Too few of them can afford the costs of research and development for the new courses they need -- ones that embody recent advances in mathematics research and in computing technology.

Issues Pertinent to Undergraduate Education in the Sciences

The contents of science curricula are discovery-driven. This creates continuing pressure on faculty members to update their courses and to develop more efficient and more stimulating ways of teaching their subjects. There is real concern in the several disciplinary communities that not enough time is being spent by faculty in this type of activity.

An example of the explosive nature of certain fields is provided by biology. The growth in discovery has been so great in this area that even new, related industries (e.g., bioengineering, biotechnology) are being created at a rapid rate.

The result in colleges and universities has been disarray. Faculty members in research universities have concentrated on keeping up with the explosion of knowledge, with less attention being given to incorporating its content into new courses, especially courses that could be taught at non-research institutions. The methods for study of biological systems, for example, have changed so rapidly that even research universities are hard pressed to keep advanced laboratory courses equipped with state-of-the-art apparatus, and few if any institutions have been able to revise the mass-enrollment introductory-level laboratory courses to reflect the new knowledge and techniques.

The emphasis on disciplinary research that has changed the nature of doctoral university faculties in the past 35 years has had a marked effect on non-doctoral institutions, which produce many of the Nation's new baccalaureate engineers and scientists. These institutions face all of the difficulties noted above, with only a small fraction of the human and financial resources available to programs embedded in doctoral universities. And in many cases their faculties, quite understandably, are beginning to moderate their commitment to improve teaching in order to spend time - an increasing part of the resources of their colleges - on basic research.

Witnesses before the Committee urged that ways be found to involve active research scientists in course and curriculum development activities that result in transferable products -- new courses and new curricula that can be adapted to the needs of other kinds of colleges and universities. They emphasized the need to replace instructional and research equipment; argued that ways must be found to reverse the falling-off of laboratory course requirements; pointed to the necessity of developing new programs to help faculty members stay abreast of their fields; and urged the very best of the teachers and researchers in each of the sciences join in efforts to improve the courses and instruction in science that are designed to meet the needs of the general student.

Comments from those who Testified Before Committee

Many individuals testified before the committee, sharing their views on the health of the undergraduate enterprise, portraying both the problems and the opportunities. Excerpts from a few of the statements are presented below:

"It is well known that undergraduate interest in basic science has recently plummeted. Within a decade the percentage of American undergraduates intending to major in science fell by 33 percent, with the absolute number of such intended majors dropping by almost 40 percent. Only slightly more than one in twenty freshmen on American campuses intends to major in science today, down from a high of one in ten in the late 1960s.[S. Frederick Starr, President, Oberlin College]

"Mathematics is both an enabling force and a critical filter for careers in science and engineering...... Mathematics is not just one of the sciences, but it is the foundation for science and engineering... The reality (however) ... is both simple and awesome: undergraduate mathematics is a totally different subject than it was twenty years ago." [Lynn A. Steen, President, Mathematical Association of America]

"We have to introduce people to the idea that science is something that is practiced, not something that exists in books ... We have to make certain that students experience the experimental side of science at the undergraduate level, regardless of major or speciality..... We have to disabuse ouselves of the idea that you can learn chemistry without picking up a test tube, or about biology without dissecting a specimen, or about astronomy without looking at the sky."[William G. Simeral, Executive Vice President, E.I. Dupont de Nemours and Company]

"It is time for the scientific establishment and the National Science Foundation as one of the leaders of this establishment to take the lead and make the commitment to reduce the underrepresentation of minorities in science and engineering."[Thomas W. Cole, Jr., President, West Virginia State University]

"Since the phase-out of the NSF programs for course and curriculum development we have seen a decrease in the flow of new instructional materials from the research universities... One element that is missing is a competitive focus for individual professors to seek funds for new teaching ideas. At a place like Cornell, the worth of a faculty member is often judged by his or her success in the competitive process of seeking research grants. A national competitive process for seeking funds for innovative teaching and curriculum improvements would also give young faculty visibility and credit in the tenure process. Without this visibility and credit, there is less incentive for faculty at institutions like Cornell to participate in innovative teaching activities.[J.M. Ballantyne, Vice President, Cornell University]

" The teaching labs in electrical engineering still make regular use of instruments manufactured in 1920, oscillators manufactured in 1940, microwave equipment manufactured in 1962, and computers manufactured in 1970".[J. M. Ballantyne, Vice President, Cornell University]

"If the research plant of higher education has been deteriorating, the instruction plant of undergraduate education in science and engineering has been collapsing" [Jon Strauss, President, Worcester Polytechnic Institute]

"..... I wish to make it clear that the Federal Government by itself cannot solve all or even most of the problems. Much of the impetus for change will have to come from the States, from industry, from scientific societies.... and most of all, from the colleges and universities themselves. [R. R. Wilson, President, American Physical Society]

"... The overwhelming consensus is that physics departments badly need new modern laboratory equipment for advanced or upper division courses, the present equipment being judged as obsolete in many respects, and that physics departments badly need replacement equipment for the introductory laboratories as well.[A. French, Pres., American Physics Teachers Assoc.]

".... when it comes to a research oriented issue there are one or two people that just care desperately about this as their number one priority .... Nobody much else cares .... it's number one on somebody's, two people's, priority list and maybe nine or ten on everybody else's...... Education may be third on everybody's priority list. It's not that it's not there. It's not that it's not important. It's just not number one; it may be number two or three....Under those circumstances... you tend to get an oversupply of the things that are number one on a few people's list and an undersupply of things that everybody thinks are important, but not quite too important." [John Crecine, Senior Vice President, Carnegie-Mellon University]

"It is simply wrong to believe that science teaching can be brought up to date by a 'quick fix' or even by more substantial, but one time only efforts.... Science teaching is inevitably rather like the White Queen in Alice in Wonderland, who siad we must run very fast just to stay where we are!"[John S. Toll, President, University of Maryland]

"The task of informing and educating the public with regard to issues involving science and technology is a formidable one, yet it is one that must be accomplished, for our democratic society rests upon the active involvement of an informed citizenry... A public that does not understand space, laser, biological, telecommunications, genetic, and engineering technology cannot be expected to support programs that break new ground in these areas."[Bernard J. Luskin, Executive Vice President, American Association of Community and Junior Colleges]

"An effective system of science and engineering education is vital to the long term interest of the United States as this country strives to strengthen its economy, its national defense, and the quality of life and well-being of its citizens. The centrality of science and technology to American life is a recognized fact, and it is evident that this Nation's future prosperity and security is dependent upon the maintenance of a sufficient number of adequately trained scientists and engineers to respond to national needs and priorities."[Frederick Humphries, Florida A&M University]

Recommendations

The recommendations developed by the Committee are presented below, aggregated by entity to receive and act on them.

To States:

- establish undergraduate science, mathematics and engineering education as a high priority of essential importance to the economic, social, and cultural well-being of their citizens;
- initiate timely and responsive considerations by legislatures of recommendations for improvement of undergraduate mathematics, engineering, and science education in two- and four- year colleges and in universities;
- enact special legislation aimed at achieving national norms for a minimum level of support for laboratory instrumentation (amounting to $2,000 per engineering or science graduate per year, as recommended by bodies such as the National Society for Professional Engineers);
- develop careful long-range plans for the renewal of facilities, equipment,

and other physical resources; and

- create special educational commissions or review bodies to determine conditions and needs in undergraduate education in science, mathematics, and engineering in their states, to help set goals and objectives, and to recommend ways and means.

To Academic Institutions:

- achieve investments of faculty, physical facilities, and financial resources per student necessary for high quality undergraduate education in science, engineering, and mathematics, through internal prioritization and allocation;
- develop both short-range and long-range plans for modernization of undergraduate instruction and research equipment;
- provide strong support of faculty efforts to update and upgrade courses and curricula designed to meet the needs of both majors and non-majors;
- increase participation by all faculty, including research faculty, in the instruction of undergraduates and in other efforts to raise the quality of their educational experience;
- foster joint efforts with other institutions to improve the school-to-college, two-year to four-year college, and undergraduate-to-graduate transitions; and
- expand partnerships in education with industries and other organizations in the private sector.

To the Private Sector:

- provide greater and more stable support for undergraduate education in mathematics, engineering, and the sciences;
- expand partnerships with colleges and universities in efforts to improve pre-professional education; and
- increase corporate efforts to improve the public understanding of science and technology;

To Mission-Oriented Federal Agencies:

- continue graduate-level programming and expand efforts to involve undergraduate faculty and students in research activities.
- consider providing incentives to contractors and grantees for appropriate inclusion of undergraduate components in their work.
- The Department of Education and the National Science Foundation should collaborate in a major effort to correct the causes of the steadily increasing demand for remedial mathematics and science instruction.

- The Department of Education and the Foundation should develop jointly data collection and analyses that will reveal trends in student achievement nation-wide.

Recommendations to the National Science Foundation:

The Committee strongly felt that the enabling legislation for the National Science Foundation obligates it to take leadership of efforts to revitalize and improve undergraduate mathematics, engineering, and science education in the United States. This leadership may be manifested in numerous ways. Convening regular meetings with state officials, academic leaders, and industry representatives to share data on the health of undergraduate science, engineering, and mathematics instruction, and to provide options for redress, is one example. Developing an administrative structure within the Foundation to serve as a national focus of activities in undergraduate science instruction is another example.

In addition to leadership activities of the type referenced above, there is a need for the National Science Foundation to provide direct programmatic support. Indeed, the Committee recommended that the National Science Foundation increase by $100 million its annual expenditures at the undergraduate level in science, mathematics, and engineering education. Furthermore, the Committee proceeded to suggest how these funds might be appropriately distributed among various program activities:

o	Laboratory Development (to support development projects to improve the laboratory component of science and engineering instruction)	$20 million
o	Instructional Instrumentation and Equipment (to encourage and support joint efforts to remedy the serious deficiencies of instructional instrumentation and equipment)	$30 million
o	Faculty Professional Enhancement (to stimulate development of new ways and share the support of the best new and traditional ways of improving the professional qualifications of college and university faculty members)	$13 million
o	Course and Curriculum Development (to encourage and support efforts to improve ways in which technical knowledge is selected, organized and presented)	$13 million
o	Comprehensive Improvement Projects (to address several of the above priorities simultaneously in a single institution, or across a given discipline, or in a combination of these through consortial efforts)	$10 million
o	Undergraduate Research Participation (to stimulate and support the involvement of ad-	$ 8 million

vanced undergraduate students in research in their colleges and in other places with programs of technical investigation)

o	Minority Institution Program (to strengthen the capability of minority institutions to increase the participation of minorities in professional science, mathematics, and engineering)	$ 5 million
o	Information for Long-Range Planning (to collect, study, and analyze information and data on undergraduate education in science, engineering, and mathematics, to assist long-range Foundation planning; this funding would include an appropriate level of collaborative work with the Department of Education and other major data sources)	$ 1 million

Response to the Report

Since the report was released there has been activity on several fronts. The NSF convened workshops of scientists, engineers and mathematicians during which the report's findings were analyzed and resolutions were passed urging that the recommendations of the report be implemented. The National Science Board carefully considered the report's recommendations in its deliberations on the FY88 Foundation budget request, which will become public when presented to Congress by the President in January. Congressional Committee have already included supportive language concerning the report in various FY87 bills. Numerous letters have been received from faculty, associations, federal agencies, and professional societies. Excerpts from some of these are presented below.

> ....the Engineering Deans Council reviewed and discussed the Report of the NSB Task Committee on Undergraduate Science and Engineering Education.... The Council concurs with the major findings of the Report that the support provided for undergraduate education in engineering, science and mathematics is inadequate to meet national needs. The Council also concurs with the finding that neither national nor NSF attention has been focused on undergraduate education which is the "essential bridge between schools and the national apparatus for research and develeopment"..... The Council strongly endorses the Report's recommendations that the NSF's Science and Engineering Education Directorate undertake a comprehensive set of programs to strengthen and improve undergraduate education in the USA. [Engineering Deans Council of ASEE 6-24-86]

> ...As President of the American Physical Society, I am writing to endorse the recently completed report of the National Science Board's Task Committee on Undergraduate Science and Engineering Education... We consider the phased in-

crease to $100 million of support for undergraduate science and engineering over two years to be very reasonable.... The American Physical Society has assigned a new, higher priority to education this year, in light of some disquieting trends in physics education at all levels, and in recognition of the intimate connections that exist among the quality of science education, the health of the scientific research enterprise, and the competitiveness of American industry. [R. R. Wilson, President, American Physical Society]

...The Committee applauds the recent National Science Board report on undergraduate science and engineering. The Committee supports the recommendation made to the States, academic institutions, the private sector, and the mission agencies. The Committee believe's NSF's role should be to provide strong leadership and leveraged program support. The Committee believes than an important and valuable linkage exists between research and educational processes which go on at this country's undergraduate institutions. ...[99th Congress, Authorization of appropriations for the National Science Foundation: Senate Committee on Commerce, Science, and Transportation; July 26, 1986]

...On behalf of the 370 state colleges and universities that make up the American Association of State Colleges and Universities(AASCU), I would like to commend the National Science Board and especially its Committee on Undergraduate Science and Engineering Education for a thorough and accurate analysis of the current problems in undergraduate science, mathematics, and engineering education....[Allan W. Ostar, President, AASCU]

....The report's detail and analytical perspective is certainly comprehensive and informative. It will be useful to this Department. We are concerned with the future supply of science and engineering manpower for the Department of Defense as well as the nation.... (David J. Armor, Department of Defense)

...The Council of Scientific Society President's (CSSP) warmly endorses the efforts of the National Science Board to focus attention on the many pressing needs of undergraduate education in science, mathematics, and engineering. We applaud the NSB Task Committee on Undergraduate Science and Engineering Education for the thoroughness and timeliness of the recently released report to the Science Board.... [Council of Scientific Society Presidents; May 14, 1986]

A Call for Action

Our universities and colleges are faced with many pressing issues today — deteriorating research infrastrusture and obsolete research equipment, being just two examples. But it is extraordinarily important that as we struggle to repair these and other similar problems we not forget the importance of our major mission of providing high quality education to our undergradate students. They are critical to the health of our disciplines and to our nation. The work of my colleagues on the National Science Board has served to highlight many of the problems to be overcome; it is important that we capture this moment and make sure that significant steps are taken now at the federal, State and local levels to achieve real progress.

I close by quoting a statement delivered in the testimony before our Task Committee by Dr. Jean Brenchley, President-Elect of the American Society for Microbiology.

> "In a society where science and technology so greatly influence our lives, we are graduating students with limited factual knowledge and understanding of scientific experimentation. We will rely on some to become future researchers while many will be leaders who serve on public boards concerned with the effects of research on their community, environment and economic development. As a consequence, we will have a society ill-equipped to make either the future scientific advances or the important political and ethical decisions affecting our lives."

The need for action is clear.

Mr. WALGREN. Thank you very much for that statement and we'll come back to it. It's strong and good.

Let us turn then to Mr. Lee.

Mr. LEE. Mr. Chairman, Members of the Subcommittee on Science, Research and Technology, thank you for the privilege of testifying before you on behalf of our 50,000 members of the National Science Teachers Association.

We have prepared written material which will be for the record. I'd like to today, however, rather than read that material, I'd like to provide a verbal summary of some of the high points, what I would consider high points; but I'd like to ask Mr. Aldridge, the Executive Director of the National Science Teachers Association to speak briefly about our budget analysis, then answer questions that you may have.

The National Science Teachers Association represents all levels of science education. Others today are speaking to the college, specifically to the pipeline. I will stress the pre-college aspects of this.

The problems in science education are well documented. It's not my purpose to go into it at this time. You know the reports, you've read the reports. We know that a large percentage of non-science-bound students do not understand what it means to study something scientifically. We know that a large percentage of our population does not understand what we mean by such terms as radiation. Yet this sizable population votes on materials, votes on bills, issues, which refer to science and technology. We obviously need a scientific and technologically literate population. Congress has recognized this in a statutory authority to NSF, with the purpose of improving the quality of education at all levels.

Our testimony today was not taken lightly. This last summer we convened a two day conference in Milwaukee, with approximately 10 or 11 national education associations, science education associations, the leaders from these people, from these organizations. We discussed the development of a science education position. Later in the summer, at a Board of Directors meeting of the National Science Teachers Association, our 28 elected representatives from all grade levels revised and refined the position statements that you have in the document today. Our testimony then, in this document, provides eight general recommendations and eleven very specific program and budget recommendations.

Our first major point is that all science education programs at the National Science Foundation be administered through the Science and Engineering Directorate. This was so strongly endorsed by our Milwaukee meeting, at our Board of Directors meeting prior to discussion of this. This came out of emotion, and it passed unanimously. We also recommend as strongly as possible the expansion and strengthening of in-service programs for teachers at all levels.

If I may interject a personal note here, I think I'm a classic example. When I graduated from the University of Wisconsin, River Falls, I had a weak background in Biology, a weak background in English, and a weak background in German, and taught all three. I was fortunate because this was the time when the National Science Foundation started producing summer institutes. Through my summer institutes, two in a row, I did receive content; I did receive the interest in going on and doing some research, which I would not have done at all unless I had been exposed to that particular summer institute; and I did go on for my experience in the summer where I received a field-based approach in one of my institutes that specifically carried over into programs that I conducted for students since 1969, in which it is a field-based one where we take students very heavily into the field every year.

But, perhaps more importantly than that, it also produced for me a network of people that were highly interested in science education. Later, I had the chance to attend an academic year institute. Still later, I had a chance to be involved in a research participation program and conducted research, rather esoteric research, but research which gave me a feel for what it would be like to be in the real world of science.

I can truthfully say I would not be here today; I would not probably be in science; very probably I would not be in teaching, if it had not been for the National Science Foundation.

As I've spoken to science meetings throughout the United States over this past year, I usually ask how many people in the audience have been involved in National Science Foundation programs. It's highly unusual if the majority of people there do not raise their hands. The majority of people that are attending science meetings in the states are like myself, old; but like myself trained through National Science Foundation summer institutes. It did provide leaders. It did keep people in the teaching profession.

Another personal example would be the Chautauqua program as is being conducted right now though National Science Foundation funds. My experience in the state of Wisconsin two years ago is an example. We had 90 teachers that were involved in a program. That particular one dealt with biotechnology, updating biotechnology. The results were rather interesting. The 90 people that were there were relatively young. They were people that had not been involved in the state Science Association prior to that. And since that time they've requested to take more Chautauqua programs, and are involved with the Science Teachers Association. They have a network and they're using it.

Another program that we would like to stress is a small grants program for individual teachers and school districts. Well that may sound mundane; it attacks one of the problems that science teachers have, and this is one of frustration. Science teachers do not have access to funds to do things. We have ideas, we have desires, but we can not compete in any formal proposal situation with the universities at the National Science Foundation, and we have proposed some form of a small grants program.

We feel that NSF should give greater systematic attention to the quality of lower division undergraduate education. This includes curriculum and faculty development. It's here that we not only train the pipeline researchers, but it's here that we also train the teachers that are going to be out teaching. These are the courses that teachers will be getting their broad education from. We also support strong applied research in science education.

I'd like to ask Bill Aldridge to analyze the budget.

Mr. **Aldridge**. I'll take just a moment if you will to make a few comments about the budget, because if you attempt to examine the science and engineering education components from the published version from the Foundation you'll find it rather difficult to translate. What we've done is offered you an opportunity to understand what the real proposal is, and we've detailed that in Table 1. [See prepared statement].

I don't think I need to spend any significant amount of time pointing out the fact that at the pre-college level, the increase over last year is zero. Now the Foundation will come in when they testify before this Committee, and make a comparison between the year 1983, when the budget was zero for everything except graduate fellowships, and the present proposed budget. That makes it look like a huge increase for science and engineering education. They will also try to show that they're providing a 16 or 17 percent increase for science and engineering education for this proposed budget, when in fact, all of that money is going to pipeline programs, and in fact, there's much of it being distributed through the research directorates.

But the fact is, that Table 1 clearly shows where the emphases are. We've made specific recommendations not just for budget, which of course is not the responsibility of this committee, but for program, and I think that's important. I think if the programs can be approved by this committee, are recommended to the full committee, we can expect the appropriations to see the advantages, and will add the additional funds.

I would like to make one added comment before turning this back over to LeRoy Lee. In the analysis of the national situation, if one looks at the demographics, I've made reference to the fact that we have huge numbers of foreign national graduate students and faculty. I don't think anybody realizes the extent to which the National Science Foundation and other federal agencies are supporting foreign national graduate students who get their undergraduate support from their own nations, where we fail to support our own students. They come over here and receive such support, at the same time that we're cutting out support for our own students. I'll cite an example for Mr. Nagle, in Iowa. At Iowa State, in science and engineering, there is $15 million provided for research assistantships. Half of that, about $7 million, is going to foreign nationals. That's in Iowa, in the bread basket, in the middle of this country. What's it like throughout the rest of the country?

My point is this: Multiply that by the number of institutions and you have approximately $200–300 million a year supporting foreign national graduate students who will go back to their countries and compete with us. So, if we want to talk about competitiveness, that's something we should be thinking about.

If there are any more specific recommendations, you can see them in the testimony. Mr. Lee has already summarized most of what we're concerned about. Thank you.

Because of the time I'll stop there. Thank you very much for the opportunity.

[The prepared statement of Mr. Lee follows:]

TESTIMONY
TO
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
OF
COMMITTEE ON SCIENCE AND TECHNOLOGY
OF
THE UNITED STATES HOUSE OF REPRESENTATIVES

IN REGARD TO

THE 1988 AUTHORIZATION
FOR
SCIENCE AND ENGINEERING EDUCATION

AT

THE NATIONAL SCIENCE FOUNDATION

PRESENTED BY

LeRoy R. Lee
President
National Science Teachers Association
1742 Connecticut Avenue N.W.
Washington, D.C. 20009

With

Bill G. Aldridge
Executive Director
National Science Teachers Association

February 19, 1987

LeRoy Lee, President of the National Science Teachers Association, is the Executive Director of the Wisconsin Academy of Sciences, Arts and Letters, Madison, Wisconsin. He is also a biology teacher at James Madison Memorial High School in Madison. His undergraduate degree was from the University of Wisconsin, and included a major in biology and minors in English and German. His graduate degree was from the University of Michigan, where he majored in biology. He has taught biology for 27 years. Mr. Lee has extensive experience in science education, including service as director of NSF and AAAS projects and activities. He has also received numerous awards, including the 1983 Outstanding Science Supervisor Award of the National Science Supervisors Association. He has published articles on science education in several journals and is presently the Publisher of the Wisconsin Academy Review.

Bill Aldridge has served as Executive Director of the National Science Teachers Association since January 1, 1980. He was a program manager in science education at the National Science Foundation in the three years prior to coming to NSTA. He taught physics and mathematics at the high school level for six years and served as a professor of physics, department chairperson for physics, and dean of a science division at the college level for seventeen years. He received his undergraduate education in physics at the University of Kansas, where he also received two graduate degrees, one in physics, the other in science education evaluation. He also has a graduate degree in science education from Harvard University. Mr. Aldridge has served as project director on several NSF curriculum development projects and is the recipient of several awards. He is the author of published books and monographs and numerous articles in physics, mathematics, and science education.

INTRODUCTION

On February 3, 1987, the Wall Street Journal published an account of what happened when the College of American Pathologists, as a test of the system, sent to 5,000 clinical laboratories throughout the United States identical blood samples containing 262.6 mg/dl of cholesterol. The returned lab reports gave results from a low of 101 mg/dl to a high of 524 mg/dl. Many of the lab test results were off by as much as 20%, and more than half had errors of 5% or more. Were these to have been real tests for real people, the misdiagnoses would have been costly and dangerous.

The College of American Pathologists attempted to find the cause of the errors and discovered several sources: instruments were incorrectly calibrated; lab technicians did not know how to use the instruments correctly; wrong chemicals were selected for the tests; etc.

The Fundamental Problem of Scientific and Technical Illiteracy.

Take the preceding example, and multiply it to include all of the devices and instruments in lab clinics, hospitals, research and development laboratories, agricultural test labs, EPA test labs, and all of the technology of our defense establishment, including that of the proposed Strategic Defense Initiative. One can easily see a fundamental problem: the lack of basic knowledge of science and technology among the many, many people who must work with the instruments, devices and other components of our technology. These persons, even trained technicians, are simply not adequately prepared for their jobs in science and technology.

Similarly, **all** of us are now exposed to a rapidly developing technology with which we must cope individually and as a society. We must make personal decisions and vote and participate as citizens in decisions that require a measure of scientific and technological literacy -- and we do not have it.

The forgoing example illustrates what numerous reports on the state of science and mathematics education in the United States have shown (A Nation at Risk; Educating Americans for the 21st Century; etc.). We are a nation of scientific and technological illiterates, and our security and competitiveness demand a major effort to assure that the whole of our citizenry, present and future, are provided basic scientific and technological knowledge. These reports show that we have little difficulty preparing enough high quality research scientists for the Nation's needs. That is why essentially all of these studies call for the National Science Foundation to concentrate additional resources on science and engineering education for **non-specialists**, instead of concentrating so heavily on preprofessional and professional education of research scientists and engineers, upon whom abundant resources are already expended.

NSF's Failure to Adhere to Congressional Mandates

Congress has recognized the important national needs in science and engineering education and codified these needs in the Statutory Authority of the National Science Foundation (Part A of title II of P.L. 99-159,99 Stat. 893). Nevertheless, the National Science Foundation has ignored repeatedly any number of these major congressional mandates by diverting education funds to the research directorates for the support of research activities disguised as science and engineering education. Mandates ignored or neglected include:

Sec 101.(a)(5)." The Congress declares that the science and engineering education responsibilities of the National Science Foundation are to improve the quality of education **at all levels** in the fields of mathematics, science, and engineering"; and

Sec 102.(a)(3)."Funds...shall...be used for enhancement of the quality of science and engineering instruction in colleges of teacher education;" and (5), "development of two-year college faculty and instructors especially in high technology fields...."

Another serious failures of NSF to meet its mandate is its apparent inability to submit in a timely and credible fashion its science and engineering education strategic plan:

Sec 107. "The Foundation shall develop a five-year strategic plan for science and engineering education, to be up-dated on an annual basis, and submitted to the Committee on Labor and Human Resources of the Senate, and the Committee on Science and Technology of the House of Representatives by **November 30** of each year."

Why was the update of the strategic plan for science and engineering education at NSF, which was to have been submitted to this Committee by November 30, 1986, 10 weeks late? Was this to avoid communicating NSF plans for SEE until the 1988 budget was already out, and the Committee might not have sufficient time to analyze the plan carefully in terms of the budget proposals? Does the description in the update of the educational programming and organization of the Foundation match Congressional expectations or is the portrayal as confusing and misleading as that in NSF's FY1988 budget documents?

The National Science Teachers Association welcomes this opportunity to detail these and other failures of the NSF in meeting its science and engineering mandates. We will present an analysis of the Foundation's proposed budget, since it reflects program priorities, and we will make specific recommendations for the improvement of NSF's programs in science, mathematics and engineering education.

DEVELOPMENT OF THE SCIENCE EDUCATION POSITION

The Milwaukee Conference on NSF Programs.

During June of 1986 the National Science Teachers Association convened a special two-day conference on NSF education programs. This conference was held in Milwaukee, Wisconsin, and included key persons from several science education organizations. The purpose of the conference was to examine NSF science and engineering programs and to prepare recommendations for the Foundation and for the Congress.

Participants in the conference were chosen for their expertise in various fields of science or science education. Organizations represented included: the Association of Education of Teachers of Science; the Council of Elementary Science International; the National Association of Research in Science Teaching; the Council of State Science Supervisors; the National Science Supervisors Association; the Society of College Science Teachers; the National Association of Geology Teachers; The National Earth Science Teachers Association; the Science for the Handicapped Association; and the National Association of Biology Teachers.

A staff member from the NSF Science and Engineering Education Directorate was invited to describe the Foundation's current educational programs. Other resource persons included the project directors from SRI International who are developing a management and program assessment plan for NSF science and engineering education activities, in response to a Congressional mandate.

Refinement by NSTA and State Chapters: Specific Recommendations.

The recommendations of the Milwaukee conference were refined further during a July 1986 meeting of the NSTA Board of Directors attended by officers of the state chapters and affiliated groups of NSTA.

In the testimony we are presenting today, NSTA makes eight recommendations for special attention by the Committee on Science and Technology.

1. The NSTA Board of Directors commends the present programs of the Science and Engineering Education Directorate at NSF, but calls for an improved balance of the funding at the different educational levels.

2. The NSTA Board agreed unanimously that "...all science education programs at the National Science Foundation, including so-called 'pipeline' programs--those involving persons aspiring to or pursuing preparation for science and engineering careers--(should) be administered through the Science and Engineering Education Directorate of NSF."

It is important to note that NSF's Science and Engineering Education Directorate staff at NSF are extremely well qualified. Most have the PhD in a field of science, mathematics, or engineering, and have college or university teaching and research backgrounds. Some SEE staff members have degrees in education and teaching experience at the precollege level. (One in that group is a winner of a Presidential Award for Excellence in Mathematics and Science Teaching.) The disciplinary preparation of SEE staff members is comparable to that of their counterparts in the research directorates of NSF.

As a group the SEE staff combine strong scientific credentials with educational backgrounds appropriate to the mission of the Directorate at all levels of education. But their number is too few and must be increased, especially if NSF's programming at the precollege and undergraduate levels is to be increased.

3. The Board recommends as strongly as possible the expansion and strengthening of inservice programs for teachers and faculty members at all levels. Present summer institute activities should be augmented with academic year institutes. The Chautauqua Short Courses Program should be extended to include college teachers. (This program, now being supported for high school science and mathematics teachers, was designed originally for college faculties. In terms of the numbers of faculty served and the very low cost, it is one of the most cost effective programs NSF has ever implemented.)

4. The Board recommended that there be "...small grants for individual teachers and school districts."

There are many instances of innovation and ideas for change and improvement being put forward by individual science, math, or engineering teachers. It is too expensive for NSF to administer a program of small grants ($2,000 to $3,000) to capitalize on such ideas. But, such a program would be feasible if NSF had new funds to make umbrella grants to universities or science education research centers so that they could administer and monitor numerous small grants, perhaps through subcontracts. For example, a university science center might receive a grant of $300,000-$400,000 to select, monitor, and support 100 or so small grants to teachers.

5. NSF should give greater systematic attention to the quality of lower division undergraduate education at both 4-year and 2-year institutions.

It is in the first two years of college that future scientists, mathematicians, and engineers receive most of their basic science and mathematics instruction; in many of the same courses, future teachers learn their science and mathematics, as do persons aspiring to careers in medicine, business, and the liberal arts.

The two-year colleges enroll more than half of all lower division undergraduates in the United States. It is also important to note that more minority students attend 2-year colleges than all other kinds of collegiate institutions combined. It is difficult to understand why the NSF chooses to prohibit faculty in 2-year colleges from competing, **on the basis of merit**, in the College Science Instrumentation Program and in other programs open to four-year colleges, or why there are no instructional development programs suitable for strengthening the 2-year colleges and their faculties. Perhaps it is because two-year colleges, although they send forward large numbers of engineering and science transfer students, are not "research institutions."

6. The Board recommended that NSF provide support for "...faculty development in both subject content areas and science teaching areas for the lower division science faculty at 2-year and 4-year colleges."

Presently there is no specific support of any kind for 2-year college faculty, and whatever undergraduate support is available excludes 2-year colleges from eligibility. It is very difficult to understand this bias on the part of the Foundation. We mentioned above that over half of the instruction in collegiate lower division science and mathematics is done in the 2-year colleges. Their transfer programs supply nearly half of the science, mathematics, and engineering baccalaureates offered in the United States. Yet NSF's programs suggest a belief that faculty development, laboratory instrumentation improvement, and curriculum updating have desirable effects only if they are done in 4-year institutions.

7. The NSTA Board recommended that "graduate students in science education be eligible for NSF graduate fellowships."

The Association's concern here is similar to that in the last item. A graduate student pursuing research on cognition (or intellectual development or pedagogy) in a particular science discipline is eligible for NSF's graduate fellowship competition if he or she is working to satisfy requirements for a degree in psychology, but not eligible if exactly the same research is done to satisfy requirements for an advanced degree in education. The fact that such research is carried out in a graduate school of education by a person who intends to continue such research should not disqualify him or her for eligibility for graduate fellowships.

8. The NSTA Board recommended that NSF support a program of "...strong applied research...that permeates all levels of K-12 science education [and] focuses on teaching, learning, and utilization."

The Directorate should define science education research to make clear the distinctions between this kind of research and that which is concerned with learning and teaching in general. Such general research, as often conducted by cognitive psychologists, should be supported only if it relates uniquely to science, math, or engineering. Otherwise, the research should be supported in a behavioral science division within the research directorate. Similarly, no applied science or education research should be supported within a research directorate, or, as in the past, SEE funds distributed to such research directorates for that purpose.

THE NSF'S PROPOSED 1988 BUDGET

Let us now examine the budget proposed by NSF for 1988.

NSF Ignores Recommendations of Its Own SEE Advisory Board and Task Force on Undergraduate Science and Engineering Education.

The Administration's proposed budget for NSF in 1988 continues to provide just token support for education in the sciences, mathematics, and engineering, while making repeated assertions of greatly increased activity. Inexplicably, the Foundation is choosing to ignore the extraordinary input received in just the past year from its own highest level advisors regarding its education programming.

The National Science Board Report on Undergraduate Education (March 1986) described the critical needs at the undergraduate level and set forth a coherent plan for NSF leadership and programming activities. That report was explicit and logical in urging that the Science and Engineering Education Directorate (SEE) take full responsibility for designing and managing NSF's undergraduate activities. Indeed, a central feature of Chapter 1 of that report called for an undergraduate administrative structure within the Directorate for Science and Engineering

Education--not in the research directorates!

The SEE Advisory Committee expressed recently its strong support for the recommendations of the NSB report, and pointed with great concern to inadequate support by NSF of efforts to improve precollege and undergraduate education in mathematics, engineering, and the sciences. This distinguished group of scientists, engineers, and educational leaders also emphasized the importance of a strong Science and Engineering Education Directorate with programmatic leadership across all levels of education. A copy of Professor Gerald Holton's letter, along with the committee's significant resolutions and actions is enclosed as an appendix to this testimony. Why are the strong recommendations of this Advisory Committee ignored by NSF (including as it does, many of the Nation's leading scientists and science and engineering educators (**Gerald Holton, Harvard; James Ebert, Carnegie; George Pimentel, Berkeley; Mary Budd Rowe, Florida; Pat Graham, Harvard; David Hamburg, Carnegie; Walter Massey, Chicago; William Baker, Bell Labs; Homer Neal, Stony Brook; Paul Saltman, UCSD; and others**)?

NSF Ignores Congressional Mandates--With Impunity.

With apparent impunity, the Foundation fails to follow the lawful mandates of the Congress. Mr. Bloch, either directly on his own, or under orders from OMB, continues to manipulate SEE budgets to provide supposedly "increased" funding levels; but careful scrutiny shows these "increases" to be thinly disguised additions for research components already bloated by years of steady increases. Equally alarming is the new ruse -- claiming that support funds for educational activities will be distributed throughout the Research and Related Activities account -- one that conceals the actual use of education funds and weakens the Education Directorate.

The following analysis of the proposed FY1988 budget reveals where the SEE funds are really going; demonstrates that precollege support has been kept essentially unchanged while no solid funding of undergraduate activities related to instruction is proposed; and shows that new support for undergraduate activities is really the funnelling of funds to the research directorates in ways that cannot even be tracked or accounted for.

TABLE I

SCIENCE AND ENGINEERING EDUCATION DIRECTORATE OF THE NATIONAL SCIENCE FOUNDATION
(millions)

EDUCATION LEVEL*	PROGRAM	FY87	FY88	INCR. 88 OVER 87
	TEACHER PREPARATION AND ENHANCEMENT			
PC	TEACHER PREPARATION	5.0	5.0	0.0
PC	TEACHER ENHANCEMENT	22.3	22.3	0.0
PC	SCIENCE AND MATH EDUCATION NETWORKS	2.0	2.0	0.0
PC	PRESIDENTIAL AWARDS FOR EXCELLENCE IN SCIENCE AND MATHEMATICS TEACHING	1.2	1.2	0.0
UG	FACULTY ENHANCEMENT	---	3.0	3.0
UG	MINORITY, WOMEN, HANDICAPPED CAREERS	---	2.5	2.5
	TOTAL	$30.0	$36.0	$5.5
	MATERIALS DEVELOPMENT, RESEARCH AND INFORMAL SCIENCE EDUCATION			
PC	APPLICATIONS OF ADVANCED TECHNOLOGIES	5.2	5.2	0.0
PC	INFORMAL SCIENCE EDUCATION	11.4	11.4	0.0
PC	INSTRUCTIONAL MATERIALS DEVELOPMENT	9.4	9.4	0.0
	RESEARCH IN TEACHING AND LEARNING	3.5	3.5	0.0
	TOTAL	$29.5	$29.5	$0.0
UG	COLLEGE SCIENCE INSTRUMENTATION	$9.5	$9.5	$0.0
	RESEARCH CAREER DEVELOPMENT			
GR	FELLOWSHIPS	27.3	32.3	5.0
PC	JUNIOR SCHOLARS	---	3.7	3.7
	TOTAL	$27.3	$36.0	$8.7
PC	STUDIES AND PROGRAM ASSESSMENT	$2.2	$4.0	$1.8
	TOTAL SEE	$99.0	$115.0	$16.0

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*PC = PRECOLLEGE UG = UNDERGRADUATE GR = GRADUATE

The Analysis: Essentially No Increase for Science and Engineering Education.

From an examination of Table I it is readily apparent that increases for SEE's precollege programs are virtually ignored in the FY1988 budget proposal. For example, despite the evidence supporting the need for substantial expansion of inservice precollege teacher enhancement activities, this successfully begun program is slated for a zero increase. Repeated calls for development of new curricular materials and for making better use of the computer in schools receive the same answer: zero increase.

As to the much touted "expansion" of undergraduate educational activities, we do applaud the minor response (relative to need) for SEE that will fund new projects for undergraduate faculty improvement and initiate new programs to meet the needs of women, minorities, and the handicapped. But note the zero increase for the College Science Instrumentation Program - and the failure once more to recognize the needs of the 2-year colleges and the universities -- despite the top priority accorded this program in the recommendations of the NSB report on undergraduate education.

The Elusive Research Directorate Budget For SEE Activities.

Table II on the following page is even more revealing. Despite our being told that NSF is "doing education" everywhere, what we see in the research directorates are large amounts of funds for projects in two principal categories: (1) the largest amounts are for still more research support, as if research were the answer to every deficiency in the collegiate curriculum -- and note that there is not a single dollar for new college level science programs for the general student; and, (2) the rest is isolated curriculum development for mathematics and engineering -- with nothing for the curriculum work in the sciences, or for redevelopment of the laboratory experience, or for any other curricular objective identified in the NSB report. Is this a coherent plan for the improvement of education in engineering, mathematics, or the sciences?

NSF claims that it has increased its commitments in "Education and Human Resources" from $30 M in 1987 to $68 M in 1988. We are left guessing as to the precise definitions of these words, but we suspect that they intend still more support for research, since the amounts are for the most part hidden among the research directorate budgets. We note also that no mechanism exists to provide oversight on the ultimate use of the funds, ie. types of institutions and regions of the country, and educational problems.

TABLE II

RESEARCH DIRECTORATES OF THE NATIONAL SCIENCE FOUNDATION

UNDERGRADUATE "EDUCATION" PROGRAMS FISCAL YEAR 1988

ACTIVITY	NSF DIRECTORATE OR PROGRAM	BUDGET
STUDENT RESEARCH	?	?
FACULTY RESEARCH AND ?	?	?
RESEARCH IN UNDERGRADUATE INSTITUTIONS	?	10.0
INSTRUMENTS AND LABORATORY	?	?
		48.5
CURRICULUM	ENGINEERING DIRECTORATE	5.0
CURRICULUM	MATHEMATICS DIVISION	2.0
	TOTAL	55.5

Major Conclusions.

We draw two major conclusions from an examination of NSF's FY88 presentation on its education plans:

(1) Precollege programs (the very area where documentation of need is strongest) are being neglected in order to put even larger amounts into the basic research system.

(2) The undergraduate college level programs that are most needed, including those for most students, are being neglected, and the few new initiatives being taken are assigned inappropriately to research directorates where staff lack interest, expertise, or commitment to improve science or engineering education.

Again, the strong recommendations of the National Science Board Report on Undergraduate Education and the unequivocal position of the NSF Science and Engineering Education Directorate Advisory Board are largely ignored or perverted in this proposed budget.

ELEVEN SPECIFIC PROGRAM AND BUDGET RECOMMENDATIONS

1. All responsibilities for NSF's educational activities at the precollege and undergraduate levels, including leadership, oversight, program management, and budget authority, should be placed within the Directorate for Science and Engineering Education.

2. Because SEE has only risen to a modest base level of funding since the Congress reinstated it in 1983, SEE's precollege and undergraduate programs should receive significantly greater increases in funding than the basic research directorates in the 1988 budget, and in the succeeding years as NSF contemplates a doubled budget.

3. The amounts requested in FY1988 for undergraduate educational programs in the research directorates should be transferred to the SEE section of the budget.

4. The precollege teacher enhancement allocation for FY1988 should be increased by 50%, raising it from 22.6 million to 34.0 million. (This will only partly make up for the fact that while the SEE budget request has gone from $113 M under the Carter budget of 1981 to $115 in this request, the research budget has almost doubled.)

5. There should be an undergraduate faculty development program concentrating at first on lower division undergraduate faculty of science, math, technology, and engineering. These faculty are responsible for 90% of all college/university level instruction. This program should include 2-year colleges, four-year colleges, and universities. A FY1988 budget of $5 M would get such a program started, with increases in subsequent years to permit work with upper division faculty. This program should include $2 M

for a college level Chautauqua short-courses program.

6. The entire curriculum development program should be located in SEE and its emphasis should be broadened to include courses for those not enrolled as science or engineering majors.

> The NSF is proposing $7 M for curriculum development to be administered in the research directorates, apparently limited to only calculus and engineering. Proposed is $2 M for revamping the calculus and another $5 M for curriculum development in engineering. There is absolutely no justification for such activities to be done outside the Science and Engineering Education Directorate, which has the expert staff and the confidence of the academic community to administer them. It is especially important at this time that curriculum or materials development in math, science and engineering at the college level be carefully coordinated across the disciplines, and not be a set of random unrelated activities. They should address not only the preparation of future scientists and engineers,but also the well documented needs of tomorrow's citizens and voters who though not pursuing technical careers will make many decisions affecting U. S. Science and technology.

7. Eligibility to compete for awards under the College Science Instrumentation should be broadened to allow faculty from all types of institutions to compete, as recommended in the NSB report on undergraduate education.

> As now offered, this program is an entitlement program for four-year colleges. It should, like other NSF programs, be based on merit and documented need, without regard to institutional type. Both 2-year colleges and universities should be eligible to compete for funds. The program's mission should also be extended to allow more advanced laboratory developments activities as called for in the NSB report. These changes will require that the funding level be increased by $10M for 1988.

8. The REU (Research Experience for Undergraduates) program should be moved from the research directorates to SEE. Research scientists with support from funding agencies other than NSF could then request support, and the present perception that only research universities and major laboratories are acceptable REU sites would be corrected. Equally important, the SEE staff can provide proper leadership and oversight for this important program. In a textbook example of poor design, the present required minimum of 8 undergraduate students on each of what are highly specialized research projects effectively precludes all but the large research colleges and universities from participating.

9. Graduate fellowship support should be broadened in eligibility to include persons pursuing research in cognition, pedagogy, and intellectual development in mathematics and the sciences. Since the number of such graduate students is small, no additional funds for graduate fellowships would be required.

10. Informal science education appears to be funded at the same level as in 1987; but increased commitments for television programming will reduce the funds available for new starts in other areas, thus actually cutting their program support levels. There is a continual need for programs in informal science education at museums, science centers, and on public television. This program should have funds increased by $3 M to permit a better balance among its project types.

11. Programs to encourage women, minorities, and the handicapped should be brought back into SEE where they can be properly administered, and where some measure of tracking and accountability is assured. The present cross-directorate system allows for questionable accounting schemes relative to women, minorities, and the handicapped, and the focus is almost entirely on programs to produce research scientists and engineers, with no attempt to assure greater opportunity of entry into this pipeline or into related careers.

CONCLUDING COMMENTS

The recommendations of the National Science Teachers Association given here are grounded on a genuine concern for the health of U.S. scientific research and for our national security and competitiveness. The science and engineering research communities interests are ill-served by the narrow view that limits NSF support to research grants and ignores the early (precollege and college) educational system that prepares both future scientists and the rest of society for a technological world. The NSF and its policy making body, the National Science Board, must recognize their responsibility to take a longer view and nurture the system that feeds the pipeline **and** prepares the rest of society for its place in a scientific and technological world.

The importance of the precollege effort is especially significant for the science and engineering research "pipeline" when one considers the following facts: from 1980 until 1992, the 18-24 year old population in the U. S. will have declined by 25%, drastically cutting the enrollments of that age group in colleges and universities. While this drop has been occurring, graduate enrollments have held steady mainly because of the huge influx of foreign nationals into our graduate science and engineering programs. Some science and engineering programs are more than half filled by foreign nationals, and already, more than half of all engineering faculty are foreign nationals. **The NSF probably spends more through research assistantships to foreign national graduate students than the entire SEE budget.** We must stimulate our own precollege system if the pipeline of U. S. students is not to be obscured by foreign nationals. The implications for defense and competitiveness are quite obvious.

In justifying minimal support for pre-college science education, Mr. Bloch argues incorrectly that a government agency with only a $1.8 billion budget cannot leverage a $250 billion enterprise like public education. But the science education component of that public education budget is only about $10 billion, and it is only the legitimate federal responsibility that is being urged upon the NSF. Consider a similar situation in the national research effort. When all forms of research, from NIH, DOE, DOD, and industrial research, as well as NSF, are taken into account, this effort is a $300 billion enterprise. How, using Mr. Bloch's logic, can a $1.8 billion NSF effort leverage this $300 billion activity? Both arguments are, of course, fallacious. In the case of the research budget, only about $9 billion is for basic research, so that a $1.8 billion research budget at NSF is very important. A similar budget at NSF for science and engineering education is just as important to our nation. It is time that the NSF recognize and act upon its **dual** mandate: "Scientific Research and Science Education **at all levels.**

HARVARD UNIVERSITY

DEPARTMENT OF PHYSICS

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December 8, 1986

Dr. Bassam Z. Shakhashiri
Assistant Director for Science
and Engineering Education
National Science Foundation
Washington, DC 20550

Dear Bassam:

This letter is my report to you on the actions taken by the Directorate's Advisory Committee at its November 17 meeting at the Foundation. On behalf of my colleagues on the Committee, let me thank you and your staff for their cooperation and hospitality.

The three Resolutions (enclosed) are of such importance that I am communicating them to you on behalf of the Committee by means of this letter instead of through the formal minutes (which cannot be prepared before the official transcript of our formal sessions is available). Additional issues raised in reports made by our Subcommittees are set forth in the brief Summary (enclosed also).

In my view, the meeting of the Committee went very well. The schedule adopted for this meeting permitted a good deal of informal discussion; this, in turn, made it possible for us to be "off and running" from the beginning. The three Resolutions have unusually forceful tone, even after the time and effort spent on each in discussion to soften both statement and diction. It is fair to say that the Committee, despite its laudable diversity, is remarkably harmonious. But I must register here that there is a strong and widely shared undertone of dismay in the Committee about evidences of inadequate commitment within NSF to its unique statutory function -- the support of science and engineering education at all levels.

1. Comment on the Pimentel Resolution. The Preamble reflects the distress of the Committee over the Foundation's failure to deter any Congressional tampering with details of its Budget Request by recommending on its own a level of funding for Science and Engineering Education that makes sense in terms of present national concerns and that is responsive to earlier, clear signals from the Congress.

We are pleased that the Congress saw fit to raise the FY 1987 Budget for SEE to $99-million. But, we are not pleased that the NSF's Budget Request was for only $87-million, just $2-million above the FY 1986 expenditure level. This request evidently invited Congressional intervention at a level of detail that should not have been necessary. Even if one likes the result, there can be a price to pay; for example, it invites further legislative involvement in the setting of priorities, and it can create a strong temptation to lobby Congress on behalf of the Directorate's mission instead of to support the Foundation's budget request overall.

The two paragraphs comprising the Resolution proper embody the distress mentioned above, and respond directly to the informative remarks made to the Committee by NSF's Deputy Director, Dr. John Moore. Dr. Moore discussed with us certain of the 62 recommendations made by Representative Don Fuqua, retiring Chairman of the House Committee on Science and Technology, but especially the one suggesting that "the Committee on Science and Technology should hold hearings to determine whether the precollege educational responsibilities of NSF should not be transferred to the Department of Education, bearing in mind the abysmal record of NSF in this area."

The record Mr. Fuqua refers to is that of the level of support of the educational function within NSF, as illustrated by his graph of the ratio ($ for Science and Engineering Education)/($ for Research and Related Activities) over a substantial period. This record may justify his choice of adjective. Nevertheless, my colleagues on the Advisory Committee and I agree with Dr. Moore that NSF's education program must embrace all levels, kindergarten through graduate school, and that transfer of any part to the Department of Education would be "a terrible mistake."

Thus, the Pimentel Resolution addresses the need for stronger positioning by NSF in seeking funds for education programs adequate to the task before us, and supports NSF's leadership at all levels of education in mathematics, engineering, and the sciences. It is essential that NSF take now all steps necessary to preempt the possibility of removal of any aspect of science and engineering education from NSF.

2. Comment on the Pister Resolution. This Resolution goes beyond the one passed by the Advisory Committee on June 24, 1986 (stating that "the [SEE] Directorate is the logical location for NSF's proposed new initiatives in undergraduate science, mathematics, and engineering education."), to urge that the Director "establish within SEE an Office of Undergraduate Science, Mathematics, and Engineering Education."

This resolution is not simply a suggestion about a detail of administrative organization. It proceeds directly from the difference between the recommendations in the Neal Report (NSB 86-100), substantiated and refined by the reports of the three Workshops on Undergraduate Education held late last spring, and the very first step taken by the Foundation to expand programming in the undergraduate area.

It is clear from the Neal Report that increased support of undergraduate research activity enjoyed high priority. The Neal Committee recommended that additional funding for undergraduate research be brought in the first year (assumed to be FY 1988) to its equilibrium level - $8-million - and that other kinds of activities be phased in over two years - but to substantially higher support levels ($42-million in FY 1988, $92-million by FY 1989). The Workshop reports clearly embraced this philosophy.

The Foundation, commendably, is getting a head start on the recommended undergraduate programming by allocating $8- or $9-million in FY 1987 to the support of research experiences for undergraduates. But, why isn't this program, like all its predecessors, in SEE -- its logical home?

Further, where is the recognition of the great importance of parallel support for work on the curriculum or on faculty development -- the other two high priorities of the NSB Task Committee and the Workshops? We can only assume that these activities are to be initiated in FY 1988 on the schedule and at the funding levels recommended in the Neal Report.

The Pister Resolution conveys the Advisory Committee's agreement with the Neal and Workshop groups: many aspects of undergraduate education are beset with critical problems; research is not the answer that should be offered to every question; and, the Directorate for Science and Engineering Education must be the focus for encouragement, development, and support of all NSF education programs.

3. Comment on the Pollak Resolution. This Resolution was prompted by information that the Department of Education is considering withdrawing its support from some of the important science and mathematics television programming currently jointly funded with the Foundation. The Resolution calls for continued cooperation in assuring support for such key projects.

I trust it will be clear from these Resolutions, from other actions, and from my comments above, that the members of the SEE Advisory Committee take their responsibilities very seriously. We are eager to be of assistance in furthering the good work that has been begun so admirably under your strong leadership. We hope that the Foundation overall will understand the importance to the Nation of its maintaining equally strong leadership roles in research and education.

Sincerely yours,
Gerald Holton
Gerald Holton
Mallinckrodt Professor of Physics,
and Professor of History of
Science;
and Chair, Advisory Committee, SEE

cc: Members, SEE Advisory Committee

Enclosures

ADVISORY COMMITTEE FOR SCIENCE AND ENGINEERING EDUCATION

Resolution Introduced by George C. Pimentel, November 17, 1986

Preamble: The Advisory Committee is gratified that the FY 1987 budget for SEE will be $12.0M above the $87.0M available in FY 1986. This gratification is tempered, however, by the fact that this is only a modest beginning toward the much larger amount urged by the National Science Board in its 1983 Report on Precollege Education in Mathematics, Science and Technology and its 1986 Report on Undergraduate Science, Mathematics, and Engineering Education. Even more significant and disturbing, though, is the fact that most of this much-needed gain was not appropriated in response to an NSF request but, instead, had to be added by the Congress. The Agency request, $89.0M, is only 2% above the funds available to SEE in FY 1986 ($55.5M appropriated plus $31.5M carryover). Such a meager rise, embedded in a budget that requests an overall 8.5% rise for the Agency as a whole, permits the interpretation that NSF does not have an adequately strong commitment to the nation's needs for better science and engineering education.

Therefore: The Advisory Committee agrees that the NSF is the proper locus for the support of all aspects of science and engineering education because of the Foundation's unique and strong linkage to the science and engineering professional community. The Committee concurs enthusiastically with the National Science Board's analyses that point to the need for a much larger national investment in science and engineering education. These two strongly held views lead us to urge the Director to ensure the NSF's leadership and control of the level of NSF Science and Engineering Education activities. This is best done by requesting and defending to Congress, as well as to the Executive sector, continued and substantial rises in the SEE budget in FY 1988. In future years, the SEE budget must move vigorously toward the levels demanded and justified in the National Science Board Reports.

The statutory authority of NSF for the development, implementation, and assessment of a full spectrum of science, engineering, and mathematics education activities and programs, integrated across precollegiate, undergraduate, and graduate education levels must be unambiguously recognized, preserved, and enhanced.

Passed unanimously.

ADVISORY COMMITTEE FOR SCIENCE AND ENGINEERING EDUCATION
RESOLUTION INTRODUCED BY KARL S. PISTER
FOR THE SUBCOMMITTEE ON UNDERGRADUATE SCIENCE, MATHEMATICS, AND ENGINEERING,
NOVEMBER 17, 1986

In the interest of advancing the strength of science, mathematics, and engineering in the nation, the Science and Engineering Education Advisory Committee calls to the attention of the NSF Director and the NSB, in the strongest way possible, its belief that NSF should develop within the Science and Engineering Education Directorate a comprehensive program at the undergraduate level. We also strongly support the proposal of the Assistant Director for Science and Engineering Education to establish an Office of Undergraduate Science, Mathematics, and Engineering Education for broadened program management responsibilities and to serve as a focal point for NSF's undergraduate activities.

The report of the National Science Board Task Committee is clear and unequivocal in recommending that SEE rapidly phase in a major program in undergraduate science, mathematics, and engineering; the NSB report was still further refined and substantiated by the three NSF disciplinary workshops hosted jointly by SEE and the NSF research directorates. Therefore, the time and opportunity for NSF both to be responsive and to take a leadership role is at hand.

The SEE Advisory Committee endorses the findings and recommendations of the NSB report and urges the Director to establish within SEE an Office of Undergraduate Science, Mathematics, and Engineering Education. This office should serve all segments of undergraduate education, including students not planning careers in science, mathematics or engineering, and promote the complementarity of research and teaching. The programs should embrace all institutions involved with undergraduate education including the community colleges, the four-year colleges, and the Ph.D.-granting institutions. The community colleges should play an important role in facilitating the access of underrepresented minorities to education and careers in science, mathematics, and engineering.

Passed unanimously

ADVISORY COMMITTEE FOR SCIENCE AND ENGINEERING EDUCATION
RESOLUTION INTRODUCED BY HENRY O. POLLAK
FOR THE SUBCOMMITTEE ON MATERIALS DEVELOPMENT
AND INFORMAL SCIENCE EDUCATION,
NOVEMBER 17, 1986

The Advisory Committee reiterates its strongest support for the development of key early education projects in both science and mathematics, such as the programs produced by the Children's Television Workshop. These programs, which reach over 3 million children each week, address a critical national need.

The Committee expresses deep concern regarding the proposed plan of the Department of Education to unilaterally withdraw from this major cooperative investment, which has been planned and developed jointly with NSF over a number of years.

The Committee urges SEE to continue providing funds for the science and mathematics television projects as planned. NSF should not consider providing additional funds to cover any shortfall due to the Department of Education withdrawal, thereby endangering other NSF projects, unless this is the only way to rescue these nationally important programs in the face of the Department of Education's failure to reverse its unilateral action.

A definite framework for future cooperation with the Department of Education should be developed; resolution of the present problem in a mutually satisfactory manner could serve as the vehicle for this development.

Passed with one abstention

The Subcommittee expressed support for the Science and Mathematics Networks program, and suggested that the networks thus established might be used to disseminate materials and models developed with Foundation funding. Existing networks can help stimulate the creation of new alliances--a process that might be facilitated with small add-on grants.

The past Presidential Awardees for Science and Mathematics Teaching represent a powerful potential network, though it is frustrating that some Awardees have been unable to accept invitations to speak because of lack of travel funds.

5. Report of the Subcommittee on Research, Studies, and Program Assessment by Mary Budd Rowe, Chair.

The Subcommittee is pleased with the assurance that research activities will be the centerpiece of the Office for Research, Studies, and Program Assessment.

The research activities of this Office can provide an essential service for other units within SEE.

The Office might consider soliciting or commissioning position papers relating to current educational issues. These papers could serve as the bases for informational fora.

Other initiatives might include a targeted solicitation aimed at assessing science education endeavors designed to benefit minority students or the creation of a center for the publication of research results.

6. Report of the Subcommittee on Research Career Development by Norman Craig, Chair.

Action has been taken on some of the recommendations of the Peer Review Oversight Committee, other responses are in progress, and some are being considered.

The Subcommittee and members of the parent Committee expressed interest in strengthening the emphasis on teaching in NSF-supported fellowship and special awards programs. For example, Graduate Fellows and Postdoctoral Fellows might be encouraged to acquire teaching experience and build dossiers reflecting such experience. Selectors for the Presidential Young Investigators Awards were urged to place greater weight on evidence of excellence in teaching and carefully consider applications from faculty at institutions that do not offer Ph.D. degrees.

NATIONAL SCIENCE FOUNDATION

DIRECTORATE FOR SCIENCE AND ENGINEERING EDUCATION

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Mr. **Walgren**. We appreciate your perspective and look forward to developing it with you.

We'll then turn to Dr. Straumanis.

Dr. **Straumanis**. Thank you.

Mr. Walgren, members of the Subcommittee, and other friends and protectors of undergraduate science education. Thank you for inviting me to testify on behalf of 28 undergraduate liberal arts colleges, including, Mr. Nagle, Grinnell College in Iowa, with whom we have direct networks for communication and consultation.

However, I hope that you hear me as speaking not just for these colleges with whom we are in direct contact and have a right to speak, but also for liberal arts science education in general and for undergraduate science education wherever it occurs.

Let me introduce myself very briefly. I'm a college administrator. I've been dean of the faculty at two different undergraduate liberal arts colleges; Kenyon College in Ohio and Rollins College in Florida. Before that, I was a faculty member at Denison University in Ohio, another liberal arts college. I would like you also to know that I spent some time at the National Science Foundation as a program officer in the late 1970's working in the Science Education Directorate on undergraduate programs. In particular, I was involved with the LOCI program, Local Course Improvement Program, the ISEP program, the instrumentation program that preceded CSIP, Instructional Scientific Equipment Program. That was the largest program in the Foundation at the time in the sense that it had the most proposals and gave the most grants. I also spent a small amount of time in community based programs supporting community museums and local government efforts in science. So, I have some background in the Foundation.

Let me say that in preparing for this testimony, in talking to people, and especially at breakfast this morning, I felt as if I was in a time warp because the things that we're saying today are exactly what we were saying ten years ago just before the demise of the Science Education Directorate. So, it feels very strange to be saying the same things about the same program, but that's what I'm going to do today.

I think it would be helpful to you to follow my testimony. I will be featuring the things that are in bold type as I go through the testimony, and elaborating somewhat on a few of them.

Let me say that I hope that we're at a stage where we are beyond token gestures and really will look closely at the details of the programs that we have already funded and that we support and that we are interested in looking for the best new kinds of programs to support undergraduate science education.

Now, why is undergraduate science education critical to the national interest? Well, undergraduate science students become scientists, and, let me add, they also become science teachers. This is a truism. It goes without saying. But it needs to be said because we sometimes act as if this is not true.

Second, the decision to become a scientist is usually confirmed in the undergraduate years. To that let me add that, unfortunately, students decide not to become scientists in the undergraduate years as well. Our figures show that more students come into college hoping to major in science and mathematics than do major in science and mathematics and graduate as seniors four years later. Those are the only fields in which this is true.

Students encounter their first research scientists during the undergraduate years. These are people who can show them what the life in science is like and can serve as role models and mentors as they pursue research together.

Next, curricular and pedagogical innovation in science is initiated and led by undergraduate science faculty. And to this, let me add, that in some cases the undergraduate science faculty and undergraduate institutions are almost the only people left who are teaching undergraduates among our faculty.

The undergraduate faculty in the large research universities more and more are turning away from teaching and being replaced by graduate assistants, people who are not yet scientists and certainly not yet teachers. I have an article here from the Chicago Tribune about a study done at the University of Illinois about the teaching of undergraduate science, and let me quote quickly from this study.

"In four years I have had only one faculty member in my major," one undergraduate said. "All the rest were graduate assistants." The Dean says, "Many of our best faculty tell us that they will leave if they are forced to teach undergraduate courses." Added a department head, "Teaching assistants are cheap labor for departments which permit the faculty to do their research."

What I'm saying is that we in undergraduate institutions continue to specialize in the teaching of undergraduates and to lead the nation in that effort in our enthusiasm for continuing to do that.

So, the four-year colleges have a special role to play in science education, and I submit that we should be asked to play that role by the Congress and by the National Science Foundation to participate in the design of programs to improve undergraduate science education.

Our productivity of scientists in our undergraduate colleges is very high. We continue to have higher rates of productivity of scientists than many other institutions, including, by some measures, the research universities. There is an appendix to my testimony which shows some of the percentages of our undergraduates from various kinds of institutions that go on to become scientists.

Now, why does undergraduate science education need the recognition and protection of special NSF programs? Because that's what we're asking for.

Well, let me say what I think should be obvious. That the undergraduate constituents of the NSF have suffered from insecurity and neglect. Even when NSF was at its strongest, there was a sense of insecurity among the community of undergraduate science. But you can imagine how that was confirmed by the demise of the Science Education Directorate early in fiscal year 1981.

Now, the present result of these past events is a degree of distrust that our permanent interests are secure in this renaissance of attention to undergraduate programs in the NSF. We applaud this new interest but it is a challenge for you to convince us, to assure us, that the structures will be in place to enable these improvements to be permanent and to give us a sense of security so that we can plan our own careers in science education and our own institutional priorities, so as to be able to depend in part upon support from the Federal Government.

Another reason why we need special programs and special protection is that the career patterns and working conditions of undergraduate faculty scientists are different from those of their graduate school counterparts. And I underline the word scientists. Our faculty are scientists and they need support, as other scientists do. So, even when the quality of their research is comparable and excellent, the pace and focus of work at undergraduate institutions is different from those at graduate institutions.

Faculty confine their research, sometimes, to summers and sabbaticals because of their heavy teaching loads. They lack local colleagues in their subdisciplines. They lack research support services on the campus. They lack contacts in the private foundations and corporate sponsors. They lack funds for travel, equipment and assistants. And, finally, the realities of teaching at undergraduate colleges require faculty members to broaden their perspectives as they continue with their careers, while at graduate schools specialization is encouraged. This means that the way a career looks and the way a vita looks is different for an undergraduate scientist than for a graduate scientist.

These things are taken into account by the research directorates and their staffs as they distribute money and to the detriment of the undergraduate faculty. Protected programs are an appropriate response to these realities.

Now, what we're asking for, please bear in mind, is competition and quality, not entitlement. We want to be part of the National Science Foundation because we believe in competition and excellence. We believe in the quality control structures and customs that are in place at the National Science Foundation such as the concept of peer review and the concept of collegiality with other scientists.

Of course, we urge that peer review be taken literally and seriously and that we be judged by those who have a knowledge of our institutions, a knowledge of our objectives and the kind of science we can reasonably produce.

Now, what are our key priorities for undergraduate science education in the National Science Foundation?

Balance has been mentioned by Dr. Neal. In fact, we endorse that remark of his and all the other remarks that he and Mr. Lee have made because we are totally in tune. I hope you see that when we talk about balance we mean, among all of the components of science education, the production of scientists and the pursuit of research. That we do not think these programs ought to be in competition with one another.

We need stronger support for existing programs. When Congressman Sabo was here in this room, I thanked him for the role that he played in the initiation of the CSIP Program, the College Science Instrumentation Program, from which we have benefitted so much in the past few years. But this is a very small program and I notice that it's level funded in the proposal for 1988.

Does this mean that we have reached an optimal level of funding for undergraduate instrumentation? This figure is $9.5 million. Please compare that with $8.9 million of late-1970's dollars in the old Instructional Scientific Equipment Program that I referred to before—sorry, that was in 1964. Forgive me, I thought it was in the 1970's. In 1964 we spent $8.9 million on instrumentation. Now we are spending $9.5 million and we're unwilling to raise it for next year.

The National Science Foundation budget summary for fiscal 1988 is puzzling to us. We don't understand the reference to instrumentation and laboratory instruction as one of the new and expanded activities proposed for the support of undergraduate science education in fiscal '88 because CSIP, which is the primary vehicle for supplying instrumentation support for undergraduate science education, is neither new nor expanded in this budget request.

So, we need help in understanding what is being addressed here, what instrumentation are we talking about? Please help us find that money. Tell us what the funding levels are, and we will surely apply for it.

Furthermore, if community colleges are to be included among the eligible institutions for CSIP support in the near future, as they definitely should be, then funding should be increasing even more rapidly now than formerly. It is really a scandal that the request is for level funding.

Let me comment on the RUI Program; Research in Undergraduate Institutions, which is our greatest hope for the support of our faculties' aspirations to be serious researchers.

We are very concerned about the meaning of an increment of only half a million dollars in this very important program. In a year when we have been hearing special promises of increased attention to undergraduate science, let me tell you, that this is one of our favorite programs, and if these promises are real, we hope to see this program given special attention.

Let me tell you another concern we have about the RUI Program. We are hearing that our scientists from undergraduate institutions who are experienced researchers and have formerly been recipients of support from the research directorates of NSF, are turning to the RUI pool for their support now that RUI exists, and are sometimes being advised to do so.

What this means is that the effect of funding for RUI is to free-up dollars for research support in the research directorates to their traditional recipients, the scientists at the research universities, increasing the competition for the dollars in the RUI program as more and more of these scientists turn to RUI. This suggests that as the program matures we ought to be receiving more money for RUI and not phasing it down, as was suggested in the original proposal for RUI. That suggested that it's a weaning program for bringing undergraduate scientists from a protected program into the regular directorates.

I suggest that NSF ought to be asked to track that proposal traffic to see how the pressure is turning and whether indeed it's true that RUI is now serving more people than it was intended to serve, or, in fact, serving different people than it was intended to serve, namely, the research scientists at research universities indirectly.

Next I would like to discuss new and revised programs to serve the special needs of undergraduate science education. Let's think of the constituencies of undergraduate science education. Let's think of the constituencies of undergraduate science education as falling into three main groups: The lower level undergraduates and nonscience majors; secondly, the science majors who are potential scientists; and, third, the science faculty.

Of course, the fellowship and research programs serve the faculty best. The research participation programs are designed for the upper division students who are hoping to become scientists. But I submit that of these three groups, the beginning undergraduate is least served by any present NSF programs.

Fortunately, we do not have to start from scratch in thinking about these students. We have past programs within the National Science Foundation that served some of these same purposes. We know how to do these things. We just simply haven't been permitted to do them for some years.

I will be nostalgic for a moment and talk about some of the programs in NSF and of the past that attempted to address problems of undergraduate science education, especially of the lower division undergraduates.

Local Course Improvement, a program that I was associated with, was an excellent example. In this program, faculty were given direct grants, small but important grants, that rewarded innovation and enabled them to experiment with their own curricula under local conditions that made sense for their own institutions. The students were the direct beneficiaries. At the time, Robert Watson and I published a directory of undergraduate science improvement projects which enabled these recipients to network with one another and share their good ideas. These programs were indexed by a key word index that enabled people to find innovative work in their own disciplines and to make direct informal contact with people who were doing curriculum innovation all over the country. Not only has this program disappeared, but so has any kind of publication or indexing system that would enable people to make contact with one another to share the ideas that have been funded by public tax dollars.

I bring this up at this point because we are happy to see curriculum initiatives return to the National Science Foundation list of priorities. We're glad to see that there will be some action on calculus and engineering education in the future. We are extremely puzzled that this funding is located in the research directorates. That doesn't make sense to us and we certainly would like an explanation of it. But, in any case, what we are suggesting here is a mechanism for carrying out some of these curricular initiatives.

Why am I putting such emphasis on foundation courses in science? I believe that our introductory science curricula are in crisis. Our entry-level science courses serve not so much to introduce and attract students to science, but to select them out of science. Some of you may have had this experience as undergraduates. These courses function as gatekeepers, especially for many women and minority students.

Now, it has been said to me by many people that the reason why people drop out of science and the numbers who graduate are smaller than the numbers who intend to graduate in these fields is because they learn how difficult science is; they learn that the details of science are not for them, and they don't have the skills. They are selected out.

I submit that this may not be true, and we need to know the truth.

After all, we have put a lot of attention to improving the writing skills of the students who come into college without being able to write. At my institution, we do a very good job of that. We put a lot of money into it, with the help of the NEH,[1] by the way. We teach students with the use of word processors and special tutors, how to write when they thought they never could.

We do not have a comparable effort with respect to quantitative reasoning or scientific reasoning. So we content ourselves with discovering the talented and frightening off the rest. The students who leave science for other fields are bright enough and they do well in these other fields. They graduate with pretty good records.

I submit that our science curricula are at fault here and that we need help in discovering how better to do these things and that we ourselves, our own science faculty, are the best people, with the assistance of their colleagues at schools of education, who help them know how students learn. And we can help our local curricula in such ways as to learn how better to do these things and to communicate with one another when we learn something useful——

Mr. **WALGREN**. Let me ask you to finish with some diligence. I want to turn to my colleagues before they have to meet other commitments.

Dr. **STRAUMANIS**. All right.

Let me just tell you that I have a few words of praise in my testimony for the old URP program, the Undergraduate Research Participation Program, the concept of which we prefer to the new design of the REU program, which requires a minimum of eight students per working group. We have been told in some directorates, in some places, that eight may not even be competitive.

Our departments are small. We are worried about whether this program will work for us. We prefer programs that are open ended and allow choice of the size of the research teams. The key note here is "choice." We would like to compete on the basis of our own proposals and have them judged for excellence.

Let me turn quickly to the questions of quality control and accountability. I have mentioned the need for publication. We also need advertising and clarity in understanding where science education dollars are going.

I have a handout here which is our interpretation of the budget for undergraduate science education. We are trying to figure out where that money is and how it is going to be used. I would like to distribute this. Some of this had to be learned from staff. Some of it had to be dug out of the budget narrative, but we still can't tell how $38.5 million are to be distributed among the various programs that are to share that money. We would like line item information so we know how this money is going to be distributed. I suspect you would like that, too.

[Material referred to follows:]

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[1] National Endowment for the Humanities.

National Science Foundation Support for Undergraduate Science, Fiscal Years 1987 and 1988

	Fiscal 1987 NSF Request ($ millions)	Fiscal 1987 Current Plan ($ millions)	Fiscal 1988 NSF Request* ($ millions)
Support from Science and Engineering Education Directorate (SEE)			
College Science Instrumentation Program (CSIP)	7.5	9.5	9.5 line item
Faculty Enhancement (New)	0	0	3.0 (staff)
Courses/Workshops/Seminars	0	0	(3.0)(staff)
Total in SEE	9.5	12.5	12.5
Support from Research Directorates			
Research in Undergraduate Institutions (RUI)	no line item	9.5	10.0 (staff)
Undergrad. Curriculum Improvement (New)	0	0	7.0 (narrative S-18)
Calculus (New)	0	0	(2.0) (staff)
Engineering (New)	0	0	(5.0) (narrative S-12
Comprehensive Program (New) incorporating	0	0	38.5 (narrative S-18)
Research Opportunity Awards (ROA)	no line item	1.5	
Research Experiences for Undergraduates	no line item	9.0	
Instructional & Research Instrumentation	0		
Faculty Enhancement "at research experience sites" (see ROA)	0	0	
Laboratory Development (curriculum)	0	0	
Etc.			
Total undergraduate support in Research & Related Activities Budget		20.0	55.5
GRAND TOTAL		29.5	68.0
Predominantly Undergraduate Institutions, including CSIP, RUI, ROA, REU (shown above) and faculty development	63.0		
Predominantly Undergraduate Institutions, including RUI and ROA (shown above)			50.0 + (Narrative S-19)

*Source of information: either NSF staff or NSF Budget Summary 1988

Let me finish by reiterating the request of my colleagues in the panel for special structures in the NSF to serve the needs of undergraduate science education. In particular, we need a Division of Undergraduate Science and Engineering Education within the Science and Engineering Education Directorate of the National Science Foundation.

This will give us the sense of security that I described as lacking in my earlier remarks.

Thank you for hearing me out.

[The prepared statement of Dr. Straumanis follows:]

Statement by

Joan Straumanis
Dean of the Faculty, Rollins College

on behalf of

The Associated Colleges of the Midwest,
The Great Lakes Colleges Association,
Connecticut College, Reed College and Rollins College

on the

Fiscal Year 1988 Authorization for the National Science Foundation

before the

Subcommittee on Science, Research and Technology
of the
House Committee on Science, Space and Technology

on

February 19, 1987
2318 Rayburn House Office Building

Mr. Walgren and Members of the Subcommittee:

Thank you for inviting me to testify on behalf of twenty-eight undergraduate liberal arts colleges[1] on the important issue of support for undergraduate science education by the National Science Foundation. I am the Dean of the Facuty at a small, selective liberal arts college in the southeast. I have had wide experience in higher education during my career, especially at liberal arts colleges in the midwest. Before coming to Rollins I was Academic Dean at Kenyon College in Ohio, and before that was a department head at Denison University, also in Ohio. My own undergraduate education was at Antioch, another Ohio liberal arts college.

During 1977 and 1978 I was a Program Officer at the National Science Foundation in the Science Education Directorate while on leave from Denison University. After my return to Denison, I remained active as a consultant to the Foundation, for example helping to administer the peer review process for the Instructional Scientific Equipment Program (ISEP), the program awarding the largest number of grants in the NSF at that time. I also managed the publication of a book (co-authored with Robert F. Watson, now head of the College Science Instrumentation Program, CSIP) indexing NSF undergraduate instructional awards. These consulting activities continued until the demise of the Science Education Directorate.

While preparing this statement, I took the occasion to read some of the testimony offered to you and your predecessors in Congress on similar occasions during the past several years. Recently the tone has been grateful and congratulatory for the resuscitation of science education within the National Science Foundation. To this applause, of course, I add my own. The developments of the past several years have given us in undergraduate education hope that our pressing needs will be addressed by the people of the United States through you, their Representatives.

But this sense of encouragement emboldens us to speak in greater detail than ever about our specific contributions and requirements. I assume that we have now passed the stage of token gestures and that this year you and your partners at NSF will undertake the work of designing and refining excellent undergraduate science programs, along the lines of the "Neal Report"[2] recommendations. It is in this spirit that I deliver these remarks.

I. Why is undergraduate science education critical to the national interest?

1. Undergraduate science students become scientists. This is a truism, of course, but it underlines the fact that every working scientist and engineer from the newest graduate to the Nobel laureate moved through an undergraduate program and, presumably, learned a good deal of science in doing so. It is folly to neglect this vital step in the sequence by which scientists are made.

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[1] Members of the Associated Colleges of the Midwest: The Colorado College; Knox, Lake Forest and Monmouth in Illinois; Coe, Cornell and Grinnell in Iowa; Carleton, Macalester and St. Olaf in Minnesota; and Beloit, Lawrence and Ripon in Wisconsin. Members of the Great Lakes Colleges Association: DePauw, Earlham and Wabash in Indiana; Albion, Hope and Kalamazoo in Michigan; and Antioch, Denison, Kenyon, Oberlin, Ohio Wesleyan and The College of Wooster in Ohio,
and Connecticut College, Reed College in Oregon and Rollins College in Florida.

[2] Neal, Homer A., for the National Science Board, Undergraduate Science, Mathematics and Engineering Education: Role for the National Science Foundation and Recommendations for Action by Other Sectors to Strengthen Collegiate Education and Pursue Excellence in the Next Generation of U.S. Leadership in Science and Technology (Washington, D.C.: Government Printing Office, March, 1986).

Testimony before the House Subcommittee on Science, Research and Technology
Joan Straumanis, Rollins College
February 19, 1987

2. **The decision to become a scientist is usually confirmed in the undergraduate years.** Unfortunately, so is the decision not to pursue a previous interest in science. Studies have shown us that more students declare intended majors in science and mathematics in the freshman year than graduate with these majors four years later. It may seem to be common sense that people lose interest in science because they learn how difficult it will be, or because they can't make the grade, but I submit that there are other reasons -- less complimentary to us as science educators -- for this depressing phenomenon. On the other hand the affirmative decision to become a scientist is likely to be the result of the influence of outstanding teachers who often become research mentors during the course of undergraduate education.

3. **Students encounter their first research scientists during the undergraduate years.** If their science teachers are teacher-scholars, as they should be, they become effective role models of life in science. Hence a theme for us today should be to strengthen the science in college science education. We are interested in ensuring that undergraduates are taught not by graduate students but by people with doctoral degrees in science, not education, and that these teachers are enabled to maintain their self-identity as working scientists throughout their careers. Fortunately, it is easy and relatively inexpensive to support these scientist-teachers. Even without much outside help they struggle to maintain research projects under conditions of heavy teaching loads, poor equipment and relative isolation from colleagues in their own subdisciplines. Some of them have performed miracles, continuing to be competitive for regular NSF research support even in the absence of sheltered programs. But more of them would be productive scientists with appropriate NSF programs tailored to their needs.

4. **Curricular and pedagogical innovation in science is initiated and led by undergraduate science faculty.** College teachers, faced with the necessity of teaching science to a heterogeneous population of beginning students and given the time and support to develop teaching methods and materials, are remarkably creative. Collectively their work has a large impact on science education at other levels -- since these people are authors of textbooks, designers of computer programs and partners in school-college programs throughout the nation.

5. **The four-year colleges have a special role to play in science education.** The undergraduate colleges deserve more acknowledgement and prominence in their role as leaders and specialists in undergraduate education. The NSF should seek the participation of these experts in designing strengthened programs for undergraduate science education. Several studies, including the well-known "Oberlin Reports," have argued that excellent liberal arts colleges produce more scientists then even the undergraduate programs of research universities -- certainly as a percentage of undergraduate enrollments but, according to some measures, even in absolute terms. (We append a study by Carol Fuller on the actual productivity ratings of U.S. colleges and universities with fourteen undergraduate institutions among the top twenty-five as baccalaureate sources of Ph.D.'s.) This is very likely because undergraduate liberal arts colleges provide an ideal educational setting for the one-on-one mentoring that influences student commitment to science. In addition, liberal arts colleges are an important source of educational innovation, both in curriculum content and pedagogical practice.

II. Why does undergraduate science education need the recognition and protection of special NSF programs?

1. **The undergraduate constituents of the NSF have suffered from insecurity and neglect.** Even when the Science Education Directorate and its undergraduate

activities were well-funded and strong during the first two decades of the life of the NSF, scientists from undergraduate institutions could never count on their welcome in the research directorates, regardless of their research credentials. During part of that time education activities were housed on the opposite side of the city from the rest of NSF, out of sight and too often out of mind. I can testify from personal experience during that period that NSF research program officers often understood little about the philosophy and operations of the Science Education Directorate, sometimes assuming that the main beneficiaries of the Directorate were colleges and professors of education, not scientists like themselves. The final blow was the dissolution of the Directorate early in fiscal 1982 and the total eclipse of support for undergraduate science. The small amount of research funds that found its way to undergraduate institutions had meager effect. The present result of these past events is a degree of mistrust that our permanent interests are secure in this renaissance of attention to undergraduate programs in the NSF. This creates a challenge for Congress and the NSF leadership: to reassure us and our colleagues of the sincerity and stability of these efforts.

2. **The career patterns and working conditions of undergraduate faculty scientists are different from those of their graduate school counterparts.** Even when the quality of research is comparable, the pace and focus of work must be quite different. Undergraduate faculty carry heavy teaching loads and may have to confine their research to summers and sabbaticals. They may lack local colleagues in their own subdisciplines and may be handicapped by the lack of research support services on their campuses. Their contacts among the private foundations and corporate sponsors of research may be limited, along with funds for travel, equipment and assistants. Criteria for tenure and promotion probably emphasize teaching and service along with research productivity, and therefore these activities compete heavily with research for the energies of the beginning teacher. Hence an undergraduate faculty member may not have the luxury of developing a serious research program until later in his or her career. Finally, the realities of teaching at undergraduate colleges require faculty members to broaden their expertise during the course of their careers while graduate schools encourage specialization.

The result of these differences is that measures of productivity -- of track record -- that apply to graduate research faculty are inappropriate for their colleagues in undergraduate settings. The competitiveness of proposals to NSF research programs is a function of all of these factors and not just of the quality of the science they contain. Protected programs are an appropriate response to these realities.

3. **We are asking for competition and quality, not entitlement.** Some years ago, we in the undergraduate science community strenuously resisted proposals to remove our support from the NSF to the Department of Education, both because we valued our collegiality with other research scientists and because we are committed to the peer review system and other quality control practices of the Foundation. We are ready and able to compete on reasonable terms, based upon the excellence of our ideas and our proposals. But we do take seriously the premise of "peer" review: that our proposals and results be judged by others knowledgeable about our institutions and objectives.

III. What are our key priorities for undergraduate science education in NSF?

1. **Balance among the components of science education: precollege, undergraduate and graduate.** The prevailing emphasis within NSF has been upon graduate education,

where the objective has rightly been to strengthen the quality of training received by potential scientists and engineers. Now we see a strong revival of interest in precollege science, also important for creating higher levels of scientific literacy in the general population and establishing seed beds for growing the scientists of the future. Nothing that I have said or will say in this testimony should be construed as anything but enthusiasm for all such programs. But undergraduate science education has been the missing link in the chain, especially in the years when undergraduate science education was virtually absent from the agenda of the NSF. At this stage large increases in appropriations are needed for undergraduate programs just to establish the balance. We urge you to continue to think in terms of absolute increases rather than percentage increases since the base levels are so low.

2. **Stronger support for existing programs.** The initiatives already taken point us in the right direction. We were grateful for the early action of Congress in supporting the acquisition of scientific equipment for our laboratories and classrooms. This initiative recognized that our faculty are eager and well-equipped to improve science education by themselves if only their laboratories are also well equipped. Congress has recently increased the support for the College Science Instrumentation Program (CSIP) but CSIP is level funded for fiscal 1988. Surely we have not reached an optimal target for funding of undergraduate instructional instrumentation with only $9.5 million, far below the equivalent of the $8.9 million the old ISEP (Instructional Scientific Equipment Program) had in 1964.

The NSF Budget Summary for fiscal 1988 (page four) lists "instrumentation and laboratory instruction" as one of the "new and expanded activities" proposed for the support of undergraduate science education in fiscal 1988. But CSIP is neither new nor expanded in this budget request. Are there other "NSF-wide" equipment programs being alluded to here? If so, we need to know which ones and to be informed of the funding levels. Furthermore, if community colleges are to be included among the eligible institutions for CSIP support -- as they should be -- then funding should be increasing even more rapidly now than formerly.

The relatively new program which supports Research in Undergraduate Institutions (RUI) has been our greatest hope for responsiveness by NSF to the research aspirations of our faculty. But this is another program which is not slated for a significant increase in funding for fiscal 1988. We are concerned about the meaning of an increment of only a half million dollars in a year of special promises of increased attention to undergraduate science. One of the avowed purposes of RUI was to wean undergraduate faculty researchers from protected funding to the mainstream programs in the research directorates. We are concerned that an opposite effect is emerging: experienced researchers from undergraduate colleges who formerly received regular NSF research grants are choosing (or being directed to) the "sheltered" environment of RUI. If this is happening to a significant degree, the main beneficiaries are the non-undergraduate researchers who will share a larger funding pool in the absence of their undergraduate faculty competitors -- and this was certainly not the group Congress and the NSF intended to assist by the creation of RUI! This trend also suggests that more, not less, RUI funding will be needed as the program matures, and that Congress ought to request that NSF study the effects of the RUI program upon proposal traffic to and from the traditional sources of research support within NSF.

3. **New and revived programs to serve the special needs of undergraduate science education.** It may be useful to think about the needs of undergraduate science education in terms of three constituencies: (1) lower level undergraduates and non-science majors, (2) science majors/potential scientists and (3) science faculty. Of course, fellowship and research programs best serve faculty, research participation

programs are designed for the upper level science student and equipment programs assist all. But of these three groups, I submit that the beginning undergraduate is least served by the NSF undergraduate programs already on track. What these students need most is a variety of curricular initiatives which provides release time and reward to the best of their teachers to develop new courses, new materials and new approaches for the teaching of science.

I have in mind small parcels of support for individual faculty members -- not to research teams or professional educators -- along the lines of the old College Science Improvement (COSIP, and its successor CAUSE, Comprehensive Assistance to Undergraduate Science Education) and Local Course Improvement (LOCI) programs in NSF during the 1970's. I was a Program Officer in LOCI and came away with the conviction that it was one of the Foundation's most cost-effective programs. It gave individual faculty members small but tangible incentives to revise their own curricula and experiment with new materials without administrative encumbrances. As an encouragement to curriculum innovation it was literally far-reaching, extending to colleges of all types in all corners of the country and reaching students by the shortest route: through their teachers. My own view is that an NSF curricular initiative, focused on introductory science but without a preconceived agenda for the direction of innovation, will have the best chance of encouraging the proliferation of good ideas in all the disciplines.

Of course, we are pleased by the request for support of new curricular initiatives in calculus and engineering education. What I am suggesting here is a proven structure (LOCI) for carrying out some of those same intiatives and extension of this good impulse to other disciplines. We don't understand the logic of locating these in the research directorates.

Why do I choose to focus attention upon foundation courses in science? Lower level undergraduates, non-science majors and students who are undecided about whether to commit to careers in science are of special concern to me as a college administrator as I struggle with the problem of how to encourage students to select science majors and to sustain those choices, once made. I believe that our introductory science curricula are in crisis. Some of our entry-level science courses serve not so much to introduce students to science but to select them out of science. They function as gatekeepers, especially for many women and minority students. To be sure, some students enter these courses ill-equipped to handle quantitative material. But this should be no excuse. Many students enter college without developed writing skills, but we devote ourselves to instructing them in such skills, and in my institution at least we succeed -- with much effort -- in bringing them to acceptable levels. But in the science and mathematics sequences we sometimes content ourselves with "discovering" the talented and frightening off the others. The students who leave science for other fields are often bright and usually graduate with reasonable records. I submit that our science curricula often select for students who are competitive, linear in their thinking or respectful of teacher authority, not necessarily for students who show creative capabilities in science. In addition, too often beginning classes are large and impersonal and have yet to fully utilize the best capabilities of computer technology to individualize the learning process and engage the active participation of students in discovery.

I hope that Congress and the Foundation will find the means to support us in curricular and pedagogical experimentation by our own faculties. Researchers in schools of education have much to teach us about how students learn, but their venues are often remote from our science classrooms and laboratories.

You have heard me praise some of the old ways of doing things at NSF. Please indulge me as I continue along those lines for a moment longer. Our second constituency of concern, the science major and future scientists, is the intended beneficiary of the interesting and just-announced Research Experiences for Undergraduates (REU) program, designed to encourage research collaboration between undergraduates and faculty members. This puts us in mind of the old Undergraduate Research Participation (URP) program, so beloved to our faculties and, I have noticed, to those who have testified at budget hearings in the recent past. But we are concerned that some of the most effective features of URP are not reproduced in REU. Grants in REU are to be awarded to researchers who can assemble groups of at least eight undergraduate collaborators, at lease half of whom must come from other institutions. We are concerned that the small science departments at even our best all-undergraduate colleges will have difficulty gathering such teams and will not be competitive for awards. As we picture the operation of REU, we imagine our students leaving to join groups at larger universities and losing some of the benefits of the one-on-one mentoring which we credit for our success in producing generations of young scientists. And one other point is too easily overlooked: student research grants at our institutions have always functioned in part as faculty research grants as well, providing our teachers with assistants and collaborators with whom they produce fine publishable research. The Oberlin studies have revealed that in our most selective liberal arts colleges about half the publications in science are co-authored by undergraduates and their instructors.

We look forward to participating in REU to the extent that turns out to be feasible for us because we love the concept. But I hope you will forgive our nostalgia for URP, a program tailored to the needs of small departments in small colleges -- but which served undergraduate students at large universities as well.

We also loved the old Science Faculty Fellowship program when it served undergraduate faculty without easy access to university resources.

The keynote we wish to strike in urging new programs and reviving old ones is this: We prefer those which allow choice, choice of venue in research centers or our own home laboratories, choice of projects, choice of mentoring styles, choice of team size. We are pleased to submit to competition and to subject our proposals to the most stringent criteria of excellence, but we cannot feel comfortable about programs which appear to design out our characteristic ways of doing science.

4. Quality control and accountability in NSF undergraduate programs. The good intentions of Congress and the Foundation to support science at undergraduate institutions must be translated into administrative practices that assure that programs and guidelines designed to funnel support to undergraduate projects succeed in this aim. Reporting procedures and other measures to increase accountability will also increase trust between the NSF and the undergraduate science community, trust that the intended funding is finding its way to its designated recipients.

The NSF Budget Proposal before us for fiscal 1988 calls for nearly $70.0 million in support for undergraduate science. We do not quarrel with this generous request, particularly if it is a stage in attaining for fiscal 1989 the $100.0 million in new funds recommended for undergraduate science by the National Science Board Task Committee headed by Dr. Neal. But we feel that we need help, as does the Congress we suspect, in locating and understanding the programs to be funded in this budget. We are asking for better adverticing of programs and reporting of program results. We hope you will specify line items instead of the vague information provided in the budget narrative. We also need help in assessing the impact of both new and old programs on the various science communities, included our own, that look to NSF for support. In particular we are watching the administration of RUI, REU and ROA (Small College Faculty Research Opportunity Awards) to assure ourselves that proposals from our institutions are fairly handled both in the drawing of program guidelines and in the review of submissions. All of us could follow these programs better if the annual NSF publication Grants and Awards were restored.

5. **Creation of a Division of Undergraduate Science and Engineering Education in the Directorate for Science and Engineering Education.** Finally, the one most dramatic move that the Congress and the Foundation can make to strengthen undergraduate science education for the present and the future is to provide a structure within the NSF charged with the mission of focusing attention on this sector of science education. Not only would a Division of Undergraduate Science and Engineering Education within SEE build trust as a visible symbol of commitment to our enterprise, but it also could be the agent for the advertising, reporting and accountability functions already mentioned and for the design and coordination of responsive new programs to serve undergraduate science education in the future.

Thank you again for this opportunity to testify before you today.

APPENDIX I

Leading Undergraduate Sources of Ph.D.'s in All Fields, Adjusted for Institutional Size

(underlining highlights non-Ph.D.-granting institutions)

Rank	Institution	All Fields Total	All Fields Ratio
1	Harvey Mudd (CA)	257	40.7
2	California Institute of Technology	1819	40.0
3	Reed (OR)	968	25.3
4	Chicago (IL)	3805	24.4
5	Massachusetts Institute of Technology	5438	21.1
6	Swarthmore (PA)	1418	20.9
7	Haverford (PA)	683	18.8
8	Oberlin (OH)	2321	17.8
9	Harvard (MA)	5554	16.2
10	New College of the University of South Florida	63	15.3
11	University of California-San Diego	362	13.9
12	Amherst (MA)	1119	13.7
	Carleton (MN)	993	13.7
	Cooper Union (NY)	602	13.7
	Pomona (CA)	1066	13.7
16	Rice (TX)	1501	13.6
17	Brandeis (MA)	893	13.5
18	Eckerd (FL)	119	13.1
19	Wabash (IN)	501	12.9
20	Bryn Mawr (PA)	593	12.7
21	Webb Institute of Naval Architecture (NY)	52	12.4
	Wesleyan (CT)	877	12.4
23	Princeton (NJ)	2713	11.7
24	Grinnell (IA)	706	11.4
25	Radcliffe (MA)	923	11.3

Source: Carol H. Fuller, Great Lakes Colleges Association

Note: Data reported here are based on an examination of productivity for all accredited institutions, for Ph.D.'s earned during the years 1951-1980. Productivity ratios were computed by dividing the average number of Ph.D.'s conferred per year (1951-1980) by the average number of bachelors degrees conferred per year (1946-1976) for each institution.

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Date of Birth: February 10, 1937

EDUCATION

Bronx High School of Science, New York City, 1950-53
Antioch College, B.A. 1957 (mathematics, political science)
University of Colorado, 1957-59, M.A. equiv. (mathematics)
University of Maryland, 1967-71, Ph.D. 1974 (philosophy)

EMPLOYMENT SUMMARY

- Rollins College
  - Dean of the Faculty, August 1986 - present
  - Professor of Philosophy, 1986 - present
- Kenyon College
  - Academic Dean, September 1983-86
  - Associate Provost, 1982-83
  - Professor of Philosophy, 1982-86
- Department of Philosophy, Denison University
  - Professor, 1982
  - Associate Professor, 1976-82
  - Assistant Professor, 1971-76
- Department of Philosophy, University of Bristol (England)
  - Visiting Research Professor (Sabbatical Leave), 1980
- National Science Foundation, Washington, D.C.
  - Program Officer, 1977-78
- Department of Philosophy, University of Maryland (College Park)
  - Teaching Assistant, 1969-71
- Departments of Mathematics at: University of Colorado, Ohio University (Martin's Ferry), Bethany College (West Virginia), Wilberforce University (Ohio), Yellow Springs (Ohio) High School and The American University (Washington, D.C.), 1957-66

AREAS OF ACADEMIC SPECIALIZATION

Philosophy of Biology, Logic, Philosophy of Science and Mathematics, Philosophy of Language, Science Policy, Women's Studies.

PROFESSIONAL ACTIVITY, CONSULTING AND SERVICE

NATIONAL SCIENCE FOUNDATION

Program Officer, 1977-78 (one year leave funded by a grant under the Intergovernmental Personnel Act). Responsibilities included administration of grant programs for higher education, instructional equipment, and community science education; on-site project evaluation; management of the Peer Review process; program evaluation; liaison with educational and governmental organizations; and design, editing and production of an index to instructional improvement projects in higher education—see publications list.

Consultant, 1978-81. Projects included contractor negotiations, management of Peer Review conferences, program evaluation.

INTERGOVERNMENTAL TASK FORCE ON WOMEN, WASHINGTON, D.C.
In 1978, worked on the "Status Report of the Carter Administration Action on International Women's Year Resolutions" for the President's Domestic Policy Staff [with Jean Lipman-Blumen].

AMERICAN PHILOSOPHICAL ASSOCIATION
Nominating Committee, Central Division, 1985–86
Mellon Congressional Fellowships Selection Committee, 1979 - present
(Annually awards grants to academic philosophers, enabling them to spend one-year terms as Congressional staff members.)
Committee on the Status of Women, 1976–83 (Chair, 1982-83)

SOCIETY FOR WOMEN IN PHILOSOPHY
Program Chair, 1982
Founder (with others), Chicago, 1971

GREAT LAKES COLLEGES ASSOCIATION
Advisory Committee for Sloan Grant in Technology Education, 1985–86
Science Advisory Committee, 1982 - present
Academic Council (elected by Denison University Faculty), 1978–82
Organizer (with others), Women's Studies Consortium and Annual Women's Studies Conferences, 1975–86

UNIVERSITY OF MARYLAND
Founding Chair, Student-Faculty Advisory Board, 1969–70

CONSULTING AND BOARD MEMBERSHIPS

Northwest Area Foundation, St. Paul, Minnesota
Higher Education Advisory Board, 1983–86
Lilly Endowment, 1985 - present
Antioch University, Ford Foundation Curriculum Evaluation Grant, 1985
Ohio Program in the Humanities/Ohio Humanities Council, 1975–86
Women's Studies Programs: Sangamon State University (Illinois), 1983; University of Western Ontario, 1980; Kenyon College, 1980

MAJOR FEDERAL GRANTS (SUMMARY)

1985–87 National Endowment for the Humanities; to support expansion of Kenyon School-College Program to Ohio rural and inner city public high schools.

1984–87 Fund for the Improvement of Post-Secondary Education, Department of Education; to develop new consortial model for combining liberal arts and teacher education.

1977–78 National Science Foundation, Intergovernmental Personnel Act grant; to fund one year leave as NSF Program Officer.

FELLOWSHIPS AND HONORS

Danforth Associate, appointed 1976
First Annual Faculty Leadership Award, Crossed Keys Honorary Society, Denison University, 1981
Omicron Delta Kappa, National Leadership Honor Society, 1981
Award for Excellence in Teaching, University of Maryland, 1970
United States Steel Foundation Graduate Fellowship, 1967-69
University of Colorado Foundation Graduate Fellowship, 1957-58

SELECTED PUBLICATIONS AND PRESENTATIONS

"Duties to Oneself: An Ethical Basis for Self-Liberation?", Journal of Social Philosophy, v. 15, n. 2, Spring 1984.

"Sex Selection: The Public Impact of Private Choices," invited paper, Rosenstiel International Conference on Developmental Biology, Gambier, Ohio, 1983.

"A Laboratory Manual for the Philosophy of Biology," Philosophy of Biology in the Philosophy Curriculum (Council for Philosophical Studies, San Francisco State University, 1983), ch. 7, pp. 72-87.

"Of Sissies and Spinsters: Shifts in Value of Sex-Marked Terms," American Philosophical Association meetings, Chicago, 1983.

"The Case Against Human Sociobiology," American Philosophical Association meetings, Chicago, 1983.

"The Sex/Value Shift: Sex Bias and Linguistic Change," invited paper, Forum for Interdisciplinary Research Conference: Language Problems and Public Policy, Cancun, Mexico, 1981.

"Changing Sex Roles of Men and Women," two articles in the Steubenville Catholic Register, and an educational program on WTOV-TV, Steubenville, Ohio, sponsored by the Ohio Program in the Humanities, June 1981.

"The Call for Feminist Theory: Is There An Answer?" in B. Reed, Toward a Feminist Transformation of the Academy: II (Ann Arbor: Great Lakes Colleges Association, 1981).

Response to Keynote Address, and Demonstration of Computer Programs, Conference: Computers and Teaching at the Liberal Arts College, Denison University, 1980.

"Computing in Symbolic Logic," presentation and demonstration, Conference: Logic and Liberal Learning, Carnegie-Mellon Univ., 1979.

A Guide to Undergraduate Science Course and Laboratory Improvements [with R.F. Watson] (Washington: National Science Foundation, 1979).

"Generic 'Man' and Mortal Woman," an essay in the philosophy of language, in B. Reed, The Structure of Knowledge—A Feminist Perspective (Ann Arbor: Great Lakes Colleges Association, 1979).

"Logic and Simulation," in E. Thorson, Simulation in Higher Education (New York: Exposition Press, 1979). Also ERIC System document #IR 004 951, cited in Resources in Education, Nov. 1977.

"Reference and Reification," lecture, Council for Philosophical Studies Institute on Human Nature, Colorado Springs, 1977.

"Philosophical Presuppositions of Assertiveness Training," broadcast on WYEP-FM Radio, Pittsburgh, Nov. 20, 1975.

"Obligations to Persons and Other Living Things: A Philosopher Looks at Abortion," invited lecture, Univ. of Notre Dame, 1973.

COMPUTER SOFTWARE AND EDUCATIONAL MATERIALS

DEMON, a proof-teacher and validity-checker, and FRAME, a set of tutorials for translation from natural to symbolic language: instructional computer programs for symbolic logic; in use at institutions in the U.S., Canada, Australia and Hong Kong. (Distributor: Denison University Computer Center.)

"JOB CRUNCH: The Affirmative Action Game," an educational simulation [with Judith Laird], ERIC System document #ED 169 819, cited in Resources in Education, Sept. 1979. [Reviewed by C. S. Greenblat and J. G. Baily in Signs: Journal of Women in Culture and Society, v. 3, no. 3, Spring 1979.]

INSTITUTES AND WORKSHOPS

Staff: Lilly Endowment Workshop on the Liberal Arts, Colorado Springs, Colorado, summer 1986; Kenyon team leader, summer 1984.
Staff: National Conference in Philosophy of Biology, Denison University, July 1983.
Participant: Institute on Philosophy of Biology, Council for Philosophical Studies and NEH, Cornell University, summer 1982.
Staff: First National Summer Institute in Women's Studies (faculty development), Ann Arbor, Michigan, July 1981.
Participant: Training Workshop for Grant Program Managers, National Science Foundation, Berkeley Springs, West Virginia, 1977.
Participant: Institute on Human Nature, Council for Philosophical Studies and NEH, Colorado Springs, Colorado, summer 1977.
Leader [with A. Fitzgerald]: Assertiveness Training Workshops (for faculty, community women and students), 1975, 1976, 1983.

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Mr. **Walgren**. Thank you very much, Dr. Straumanis. We appreciate that presentation. We certainly will try to work with you to develop some of the areas of concern that you have raised.

Let me ask Dr. Neal and Mr. Lee; I heard you saying essentially a zero increase in a number of the important areas of this range of education by the NSF, and yet Dr. Neal is saying they have come up with $50 million this year.

Is that inconsistent? How are those two views reconciled?

Dr. **Neal**. I will just comment on the response to the report of the task committee. Our request was for a $50 million increase in fiscal year 1988. The Foundation's response was a $38 million increase. Those are in fairly specific programs, which I don't believe were being referred to in our remarks.

Mr. **Aldridge**. May I respond? If you look at our Table 2 [see prepared statement] you will see a number of question marks. Those question marks represent the location of those funds. They have nothing to do, for example, with pre-college or undergraduate for those students other than ones who pursue careers in science and engineering.

The large problems at the undergraduate level are for the students who are not likely to pursue such careers. At the pre-college level, the problems are huge and again, the budget shows absolute level funding in all programs and the only one that is claimed by the Foundation to be pre-college, for which there is an increase requested, is within the Studies and Program Assessment area, where they are going from $2.2 to $2.4 million.

But try to find that in any of the Foundation documents, it really takes a big effort to get this kind of information.

Mr. **Walgren**. Let me ask you, Dr. Neal, on page six of the formal report, you indicate a range of recommended allocations of the $100 million and the $50 million. Has NSF responded to that range that you have recommended? Can you comment on their distribution compared to yours?

Dr. **Neal**. Yes. I have experienced, of course, some of the same difficulties of trying to extract in the same terms that we have listed here, precisely what the NSF intends to do with the $38 million increase. It is fairly difficult at this stage and it may be difficult for them because they are still, I think, trying to decide how the funds should be distributed amongst some of the categories.

The remarks that I made on the basis of increase to the Foundation, I have been able to determine that instead of the $20 million that we had recommended for laboratory development and instrumentation for fiscal year 1988, the amount will be more like $11 million.

In my prepared remarks, I had expressed some concern about that, because the equipment problem is a very massive one. Studies done for undergraduate engineering, for example, have shown that nationwide, the problem is about a $2 billion problem. We are not expecting any Federal agency to solve that entire problem. It is primarily a state and institutional problem.

On the other hand, I think we do know that leadership at the Federal level, the leveraging that can be brought about through well managed programs at NSF, can result in states and municipalities and institutions solving the problems of this nature.

Instead of the $20 million that we had asked for, it looks like there will only be $11 million available. On the other hand, the undergraduate research component, the NSF may have funded that at a higher level than we had asked for. In my remarks, I have asked that a review be made on that distribution.

Mr. **Walgren**. Let me turn to others on the panel for points they might like to pursue. I recognize first, the ranking minority member and then turn to members in order of their arrival. First, Mr. Boehlert?

Mr. **Boehlert**. Dr. Neal, first of all, I want to commend you for your report.

Mr. **Walgren**. These mikes seem low. Can you folks hear in the back?

Mr. **Boehlert**. We will speak up.

Dr. Neal, what do you think? Should the NSF programs be open to community and junior colleges? I happen to think they should be so I am prejudiced. You tell me what your feelings are.

Dr. **Neal**. That was an issue that we discussed quite a bit in our deliberations.

Mr. **Boehlert**. Could you pull the mike a little closer?

Dr. **Neal**. Sure. That was an issue that we discussed at some length during the work of our task committee. On the one hand, we recognized that many students who go on to become scientists and engineers get their start in community colleges or get turned off. We lose a lot because they got turned off at the community college level.

I think it is fair to say that the members of the committee thought there should be some program to assist those colleges. The only sort of down side to that is that the resource needs to the Foundation would increase significantly. But that is just another way of stating that we are not making the proper investments in science education.

Mr. **Boehlert**. There is no question in your mind that we should do it?

Dr. **Neal**. No question in my mind.

Mr. **Boehlert**. We just need the additional money?

Dr. **Neal**. The issue, it branches off into many other areas that are of interest. For example, you will find a much larger fraction of the minority students in classes in community colleges.

Mr. **Boehlert**. Right.

Dr. **Neal**. That is the one at the first opportunity to make a change, in the number of minority students who would find science interesting and then conclude they should proceed.

Mr. **Boehlert**. If it was up to me, I would start the support in the day care centers, quite frankly. We wait too long. We wait until they get to their fifth year of study and then we start saying, well, we are going to make some commitments in dollars.

Dr. **Neal**. That's right. I should comment that one member of our task committee, who is the president of a four year college, and who participated in this discussion we had in the task force, pointed out that over 50 percent of his graduating students got their start in a community college. It is a significant number.

Mr. **Boehlert**. I am just familiar with the community college system in New York State, as you are. It is an excellent program.

Dr. NEAL. Yes.

Mr. BOEHLERT. I agree with you. We need the additional money. You are preaching to the choir, incidentally, up here. We are very supportive. This Committee has a reputation of being non-partisan, if you will, and extremely supportive. I am almost a cheerleader for the NSF.

Mr. Lee, what has been your experience on the summer institutes? How well is that program working?

Mr. LEE. I haven't attended one personally now for a few years. However, if you look at them in terms of content, it is like any other course that you take, it depends on how it has been set up. My premise is there is so much more that goes on in summer institutes besides the specific content. Content is very important for teachers, but so are the networks that develop, so is the enthusiasm, the training that comes out of it. It is much more than just content.

Mr. ALDRIDGE. There is a recent research report out of the University of Iowa which indicates that the in-service programs, the summer institute programs, produced improvements in the performance of the children and the courses which these people are teaching. That is solid evidence. It is from a report. I will be happy to provide that to you, if you would like to see it.

Mr. BOEHLERT. Is there a great demand on the part of the high school science and math teachers for the summer institute program? Before I let you respond, let me say I read this morning in U.S.A. Today—they had a chart. They are great for charts in U.S.A. Today. It was on average salary levels. In New York State, and we are second only to Alaska, the average salary, and I think they are a little bit high, for high school teachers, is $30,000. I think that is high. I will assume their research is more accurate than my experience would indicate.

It seems to me that the high school science and math teachers have to run out in the summer and make some bucks someplace to supplement income and they don't have the luxury of going to a summer institute unless there is some sort of stipend, more than adequate stipend.

Tell me about it.

Mr. LEE. There is no simple answer to that one because, yes, there are a lot of teachers that do work outside and can't afford to attend a summer institute, even with stipends. I can give you some specific examples of a uranium geologist. When the uranium bust occurred in Utah he decided to go into teaching and we tried to have him involved in a summer program and he had to run his farm during the summer because he needed that income. That is a problem.

We also find a large number of teachers that do have two spouses working. Both spouses are working. Therefore, the income is up there. You don't always have to provide summer funds for them. There is a certain group that are more than eager to come out, especially within their own entry level.

Mr. ALDRIDGE. Just a quick comment. The interest is very strong, even with small stipends. We are running a program now, a computer program, where the person has to pay to attend. We fill those up. There is a very strong interest if one can offer such programs. There is no question that is an essential ingredient and ought to be strengthened in the programs that exist.

Mr. **Boehlert**. I am just absolutely committed to investing more from our Federal Treasury in science and math education. One of my great concerns is that young people are turned off rather than turned on. I would venture to say in many school districts around the country, we have so-called science teachers who had their undergraduate and graduate training in history or in French or in something other than science, which explains why I got a D in high school physics. I was turned off.

Thank you very much.

Mr. **Walgren**. Thank you, Mr. Boehlert. The Chair recognizes the gentleman from Louisiana, Mr. Hayes.

Mr. **Hayes**. I was taking a look at some of the testimony. I am sorry I had to leave and I apologize.

Could you explain to me, and let me draw upon your expertise, in understanding completely what might be regarded by some members of the teaching community as a trade-off between teaching and research, where they feel that perhaps it is difficult to do both and where the benefits of doing research can be implanted back in the classroom. I would very much appreciate the benefit of your comments, anyone who would care to elaborate.

Dr. **Straumanis**. I would like to try to address that because that is a daily issue for a Dean in a Liberal Arts College. Our faculty are judged. They are assessed on both criteria, on teaching excellence and on their research productivity. This makes it difficult for them to know where to put their energy except that they get a clearer signal than the undergraduate faculty in the larger universities, where they are paid to teach and their contracts are to teach but in fact, all forces push them toward research.

I think the answer to it is that the best combination is the shared emphasis and all of those forces which tend to create incentives to do either exclusively or either mostly, that is, mostly teaching without research or mostly research without teaching, are contrary to the interests of science education.

Our teachers are better teachers when they are researchers. Their students become collaborators in the research. There is no distinction at my institution between teaching and research at the upper division levels.

Dr. **Neal**. I will add to that. At a major research institution, typically the faculty member spends roughly 50 percent of his or her time in instructional activities and the other 50 percent on research. As was just pointed out, the ideal arrangement is if that successful research program has the provisions to involve students, at both the undergraduate and graduate levels. I think that is viewed by those of us in university administration as being the optimum.

We would not want to see the situation where a faculty member did all of his or her—invested all of his or her time in research or all of their time in teaching.

It is a complicated matter. When the research pressures are on, there is the well known tendency for a faculty member to complete his or her lecture and then have to dash off to the laboratory and close the door. That's one of the things we have to watch out for, I think.

A faculty member who is successful in research and who cares about undergraduate students and brings them into their research program, that is optimum, I think.

Mr. **Aldridge**. Mr. Hayes, one of the problems that is facing the instructional part at the universities is the fact that the very large increases in research support by the Foundation, for example, is encouraging the senior faculty to spend all of their time doing research, pushing off onto the teaching assistants the job of instruction. Those teaching assistants are the foreign nationals who do not know how to speak English. That is one of the fundamental problems that you have in undergraduate education that is not being adequately addressed.

Mr. **Hayes**. My sister was a professor at the University of Southwestern Louisiana. That is why I have some familiarity with the balance of doing research and classroom instruction. The financial pressure became greater and she had to resign her position and go to work for a bank where she had a higher salary.

We also sympathize and understand, and I am sure you appreciate, the funding needs. As I said, the Committee has supported that.

Mr. **Walgren**. Thank you, Mr. Hayes. The gentleman from Ohio, Mr. Nagle.

Mr. **Nagle**. I really have no questions, Mr. Chairman. I will pass.

Mr. **Hayes** [presiding]. Ordinarily, I would recognize Mr. Buechner, but I know him and I am certain he could add nothing whatsoever to this. Mr. Buechner was recently my guest in the City of New Orleans. If he asks a question you don't like, you tell me and I'll ask him one you will love.

Mr. Buechner.

Mr. **Buechner**. Just so you know being elected doesn't guarantee you any respect.

I would like to ask Dr. Straumanis a question. I was looking at the list of the colleges that you represent, Doctor, and I have contributed a significant amount of tuition to one of them. [Laughter.]

Dr. **Straumanis**. Thank you very much.

Mr. **Buechner**. My son went to college in Wisconsin and having been a product of a small midwestern liberal arts college myself, although it was interfering with my football career, I note the ongoing problem that these institutions have in providing the type of true liberal arts education which is at least in my concept, math, science and the arts; and you try to create an overall balanced man and woman to go out into society. In many of those institutions, I know it is very difficult for them to attract the dedicated science and mathematics teacher when they have to provide an environment that compensates in a way for what they as a scientist or mathematician may be able to find at a larger academic institution. The same thing in a way applies to getting the dedicated science or mathematics high school teachers.

If we provide the money on a free and open basis to undergraduate schools, what type of incentives do you see in the use of that money? Can you give us a requirement to ensure that some of these young men and women that will be turned on to science will become educators? It is really something that bothers me. We will find the ones that can do the shuttle and they can do the space platform and probably make a bigger weapon. I am interested in the ones that will then be able to come to class and touch as many new students that will then become the generation beyond in terms of science.

Dr. STRAUMANIS. Yes. This is the recruitment season. I am bargaining for faculty, trying to get faculty to come and teach at our institution. What you are asking now is about how to recruit undergraduates to go into careers in science and in science education.

My answer to that is I believe that we have more ideas that we can come up with than have already been tried. For example, I am the author of a program that was funded jointly by FIPSE (Fund for the Improvement of Post-Secondary Education) and NEH for the recruitment of undergraduate liberal arts students into pre-college education by the following means: it is a five year program called Five Step, in which the professional teacher education year is taken in the midst of their liberal arts training.

They spend three years at the liberal arts college, then their fourth year, a full calendar year including the summer, is spent in the professional teacher education courses and student teaching at a professional graduate school, at a graduate school elsewhere. The liberal arts college can't provide those courses with the quality that we need and in the amount that we need. They come back to the liberal arts college to complete their major with a new knowledge of what they need in their major to be teachers.

The number one question, the number one problem in administering that program, which is in effect now at Kenyon College, is that we needed scholarship money because the rich kids are not interested. It is the middle class kids, the lower middle class kids, whose parents are teachers, who think in terms of careers in education and are not used to the idea of big bucks, and those are the kids we want and those are the kids who want to be teachers, but they can't even afford the programs, because they are already in debt for their undergraduate education.

My suggestion is that we put a lot of money into earmarked scholarships for people who might become pre-college teachers or even college teachers and perhaps earmark that for science. I think that earmarked money for scholarships for people who want to go into education is a perfectly good use of public money.

Mr. BUECHNER. Thank you, Dr. Straumanis.

Mr. HAYES. The gentleman from North Carolina, Mr. Price.

Mr. PRICE. Thank you, Mr. Chairman.

I will just speak of my own experience in teaching and counseling undergraduates, and it may be a bit out of date. I get the impression in the last number of years that the vast majority of students get initially into science courses and sometimes into science majors and it has been people looking toward being doctors and pre-med.

I wonder what your view would be about what kind of alternative career tracks would be more in the national interest and also how we might take some of these students and turn them onto other kinds of scientific careers, and particularly careers as research scientists.

To what extent can our NSF efforts turn undergraduates onto other kinds of scientific endeavors? To what extent have we been successful in doing that?

Dr. **Straumanis**. Let me address that with respect to the programs for research collaboration. I think that is your key.

When the undergraduate students are doing research as undergraduates, they begin to be interested in the scientific questions themselves and not just the career, the careerism that they might have started with. Of course, it is a very attractive career to go into medicine. They are not necessarily thinking about science and medicine. They are thinking about other things. The respect in medicine, the money in medicine and so on. When they have undergraduate research experiences, they begin to think about the science in medicine. Even if they go to medical school, they might contribute to the scientific progress of the nation.

My suggestion is also that all of them will be attracted to do more research at the graduate level and many will go to graduate schools in which they are doing pure science and not just to medical schools.

I, myself, have seen many people begin college by saying, I want to be a doctor, and then they go on and they major in biology and they end up with Ph.D.'s in biology or ecology or microbiology, cell biology, something like that. That is a contribution to the national need.

My view is that we need a good deal more research scientists from our own country and not just from abroad, although I welcome the fact that so many students from abroad are interested in science. I think it is a global problem.

Mr. **Price**. I wondered to what extent we are able to offer students that kind of experience and I expect that often we are simply servicing a large number of pre- professional students.

Dr. **Straumanis**. That is expensive. It is expensive because it is one on one. With the REU program, it is eight on one. We are worried about that. Eight on one is not the same as one on one. We can't muster that kind of critical mass at our smaller colleges, and yet our smaller colleges can turn out many more scientists than the numbers would suggest because we have these mentoring relationships already in place. If we had the summer stipends—these are not expensive programs.

I administered one using private money at Kenyon when I was Dean there, that cost us $1,000 per student per summer. That was enough. The students applied for it at that level of funding. That is a research partnership type of effort that produces scientists.

I guess my main point would be that the curriculum introduces people to science and attracts them to science but the research partnership turns them into potential scientists.

Mr. **Price**. I wonder if you could comment more generally on trends in undergraduate majors, and I know that some of that is contained in these reports. Are there any findings that you would like to highlight as far as the trends you have seen there?

Dr. **Straumanis**. I wish I had figures but the Oberlin reports are very good in that respect. We can certainly get you that information and we will. Oberlin College, as you know, sponsored two annual programs. Mr. Walgren was present at one of these. The statistics gathered in connection with those conferences would answer some of your questions.

In particular, the number of people majoring in science is going down continually. It is going down more slowly at the undergraduate liberal arts colleges than it is at the comprehensive universities.

Mr. PRICE. The trend is in the opposite direction in engineering; is that right?

Dr. STRAUMANIS. For engineering, I am sorry, I can't answer. I can say that in the social sciences, the trend is the opposite. Of course, the social sciences are of importance to us. The students are majoring in economics and business.

Dr. NEAL. I might add that on page 17 of this report, there are several charts, taking us up through 1983, that provide some of that information. It would be of interest to have data through 1986.

Mr. PRICE. I think some kind of updating of that data and updating the charts on page 16 and 17 of the National Science Board report would be very helpful.

Thank you, Mr. Chairman.

Mr. HAYES. I would like to acknowledge the fact that the State of North Carolina at this time of the year is extraordinarily interested in physics and seminars are held on predominantly Wednesday and Friday evenings at the universities throughout the State of North Carolina, where the observation of the three point shot dominates those hearings.

The gentleman from Texas, Mr. Chapman.

Mr. CHAPMAN. Thank you, Mr. Chairman.

Let me ask a general question and talk about this competitiveness in this country and addressing the issues from the standpoint of policy, of what we can do in the Congress to assist in perhaps correcting what is a real deficiency in the things that you have discussed here today, and the role that we in Congress can play through NSF and perhaps other Federal agencies in solving a problem, real or perceived, of losing the competitive edge in a world of global economy.

What I specifically want to ask of anyone on the panel or all members of the panel is to what degree do you perceive the problems that you have seen as contributing to that overall problem and is NSF moving in the right direction to correct that? If not fast enough, what would you change if you were here to accelerate that process?

Dr. NEAL. The technological competitiveness of a country is related in a fairly direct way to its manpower, to the technically trained manpower. It is well known that we are lacking, I think, in the number of engineers that are required in several areas, even in the academic area.

Just a couple of years ago, there were 2,000 engineering faculty positions open at our universities across the country that could not be filled with qualified faculty, even though the institutions had the money and the line to make the appointment. That has other ramifications.

Institutions who did get by got by with larger classes and not able to give the kind of attention to students that they should have been getting. Presumably, some students dropped out as a result of not finding that an attractive career option.

The development of a trained technical workforce is certainly one direct way that a country establishes competitiveness in the global economy. There are many other ways. Certainly, the fundamental research done now will affect the knowledge base that we would have several years from now and that will certainly in a very real way determine the competitiveness.

With regard to what should be done, I think many of the issues that we are talking about here would have a direct bearing on improving the situation in the years that lie ahead of us. Regarding the four year colleges, I believe it is true that even though most people think of the very large research universities as being the creators of essentially all of the engineers, I think we create a minority. I think almost 50 percent of the engineers that are graduated these days do get their degrees through the liberal arts colleges.

That is another reason for certainly giving attention to the needs of four year colleges. The needs that we identified in our study of needing to provide equipment. It is not right that we graduate students with a degree, presumably having achieved a certain degree of mastery in their field, and knowledge without the basic instruments that are used in their field; they go out to industry to start work and one of the first things they have to ask is, what is that?

There is another document that I will be submitting for the record [See attachment to prepared statement]. It contains comments made by several people who testified before our committee. If I am successful, what I would like to do is find just the comment made by the Senior Vice President at Cornell who testified before our committee. His name is Dr. Joe Ballantyne. This is for Cornell, one of our country's best institutions.

> The teaching labs in electrical engineering still make regular use of instruments manufactured in 1920, oscillators manufactured in 1940, microwave equipment manufactured in 1962, and computers manufactured in 1970.
>
> That is not the way to graduate a person, put them in a new job and expect them to start making earth-shaking discoveries any time soon.

Mr. CHAPMAN. Let me ask you the second part of that. The recommendations and the things you have pointed out here in your study, has NSF in your opinion, responded appropriately? If not, and someone else may want to address this, what can we do here perhaps to prompt a greater reaction to make that response a little more appropriate? Or, does NSF have a role?

Dr. NEAL. Yes, absolutely, NSF has a role. The request of our task committee was that NSF should boost its budget in the undergraduate area by $50 million for fiscal year 1988. Their response—their total response was a $38 million increase. We don't quite know just yet into which categories that $38 million is supposed to go. That was NSF's response.

As I indicated, I had hoped certainly for at least the full $50 million and that coupled with this five year plan where the NSF budget is supposed to double, I would certainly hope that this opportunity would be taken to make a major increase in support for undergraduate science and engineering education; much more than the $100 million even that our committee had recommended, sort of in the context of the overall current NSF budget. I think those would be funds very well spent. The kinds of activities that we have discussed are the ones that need attention; equipment; faculty development; undergraduate research participation. Those are the pressure points, I think, where the country can make investments and a few years from now, see the results of those investments.

Dr. **Straumanis**. And curriculum. I would like to add that we definitely support those figures from the Neal Report. We agree that we should be on our way to in excess of $100 million within two years. We think the key to the answer to your question is balance. We have talked about chains with the weakest link. We have talked about pipelines that aren't full. In general, we have to look to see where in this sequence of events what moves ordinary kids to become scientists, Nobel laureates or technical workers; where in that pipeline is the funding too thin.

I think we have generally agreed that it is far too thin in the undergraduate years. I would add that to my mind, the curricular innovations are the most important factor for maintaining a long term investment in competition. I think we need to have better courses. I will say it one more time. I really think we are taking students out of science, not putting them into science. We have to figure out how to get more kids to maintain their present interest in science as well as attracting more into science.

Mr. **Aldridge**. Mr. Chapman, may I respond to that?

Mr. **Chapman**. Please.

Mr. **Aldridge**. If you look at Japan, for example, the basic research which goes on there is minimal. That country depends very strongly on the basic research conducted in this country. Your emphasis at NSF has been in the support of basic research, very large amounts of support, with support for the pipeline system feeding the research activity.

If you look at Japan, however, you have a population of managers and workers who are technologically literate and are able to utilize the basic research results that come out of this country to become competitive against this country.

The NSF is totally ignoring the responsibilities for the general population of managers, technicians, workers in fields other than research science, and in many ways, eating their seed corn in regard to the pipeline. It is that sort of emphasis that we stressed in our testimony and we would urge you to include the kinds of programs that would address that population, which would in itself require additional funding. You would have to obviously phase that in. It certainly would be reasonable to expect 15 to 20 percent of NSF's budget for science and engineering education activities within the next two or three years.

Mr. **Chapman**. Should this Committee increase the requested amount of funds in this area, is that where the money should go?

Mr. **Aldridge**. Well, there are two things that can be done. You can take some of the funds that are proposed for the research directorates that are really science and engineering activities, move them into the Science and Engineering Education Directorate where it can be better utilized. Second, you can broaden your support at the undergraduate level to include those four year colleges and two year colleges that prepare not only the scientists, but prepare the teachers and the pharmacists and the technicians and all the other people who live and work in this society and need to understand something about science and engineering.

You are in a position to influence that and the vacuum of support at NSF for that undergraduate component is very serious.

Mr. **Chapman**. One final question. In your comments previously, you addressed the number of foreign nationals that are receiving the benefits, I guess, primarily of post-graduate education; thereby, funded with a lot of our tax money. I think the number was $200 or $300 million.

That would be a great line back in my home district in Rule, Texas, at a town hall meeting, if I stood up and said I would want to try to stop that kind of foolishness, educating Japanese engineers and technicians and scientists to go back and compete against us. However, that may or may not be a rational statement to make.

My question to you would be again, if you were here, if you were wearing our hat and presuming by that comment, that might be less than optimum use of those resources, what should we do differently?

Mr. **Aldridge**. The argument that is made by the institutions is that we want to take the best and the brightest and these happen to be the best and the brightest. My response to that would be if you really believe that and you were to take the best and the brightest from the People's Republic of China alone, you would fill every single graduate slot in the United States.

Where do we draw the line? Where do we support our own young people and give them an opportunity? I don't think you should stop supporting foreign nationals. I think you should start supporting the people in this country in addition to the support for foreign nationals.

Dr. **Straumanis**. And don't stop supporting the foreign nationals until we have enough Americans to fill the slots in our teaching. For example, we have three openings in my Department of Computer Science and Mathematics right now, that I am trying to fill. Over 60 percent of the applicants are foreign nationals. They are the best applicants as well. The Americans getting Ph.D.'s in mathematics and computer science are being grabbed up by industry. I am going to have to fill all three of those positions with foreign nationals. If we stop supporting them, I won't even have a mathematics program.

Mr. **Chapman**. Thank you, Mr. Chairman.

Mr. **Walgren** [presiding]. Thank you, Mr. Chapman. Mr. Mineta.

Mr. **Mineta**. Mr. Chairman, thank you very much. After listening to the panel, I am so depressed, I'm not sure I have any questions.

You do point out this whole issue, for instance, eating our own seed corn. That is a very apt one. I was just talking to the head of the Chemistry Department at San Jose State. They were looking for a new Assistant Professor in Chemistry, a Ph.D., five years of experience, offering $20,850. I happen to be in the middle of Silicon Valley. Anybody who has a Ph.D. with five years of experience could do a heck of a lot better than that or even if they wanted to take $20,850, could go to work for one of the start-up companies in our area with an employee stock option program and be a lot better off than going to San Jose State as an Assistant Professor in Chemistry.

I am just wondering—I apologize for not being here earlier—is NSF's role to increase the scientific literacy of the populous or is it to direct or have opportunities to have young people to go into science and engineering, to make sure we have the sufficiency of the teacher core at the high school level and at the teacher college level as well as the professional scientific teaching core, in terms of the basic sciences?

Given the limited resources that we do have, it is nice to be able to say, yes, you ought to increase it by tenfold in five years or double it in five years or whatever, but I also was out at a park in San Jose last Sunday where Bubba Paris, a football player from the 49er's was giving out 185 pairs of shoes to homeless people. He happens to represent Muzuno Shoes. He gets a monthly allotment of 100 pairs of shoes and he decided he was going to give his 100 pairs of shoes to the homeless, the shelterless, from now on, and not to high school athletes.

We have priorities that we have to try to deal with as well. Given this, where should we put our emphasis?

Mr. LEE. That's a very difficult question to give a simple answer to. Within the realm of science education, science, science and technology progress does not take place in a vacuum. It is very closely related to society. I think as we have been saying through here, if you develop two cultures, those that are the scientists and those that have no science and are not interested in science and are afraid of science, you are really developing two cultures.

To be able to have—the ideal would be to have a populous that would be so demanding of a good science education that they would want to raise that $20,800 to the rate at which they could be paid in Silicon Valley. We are not putting our money, in my estimation, at the present time, into a broad general education of science and technology for the majority of students, speaking now specifically of undergraduates but I assume also pre-college, the majority of students who go out there and are the core and are the voting core.

Dr. NEAL. I would like to comment on the issue of the mission of the Science Foundation. It is something we had to go back to and look at, just to remind ourselves what the charter of the Foundation was, as we were doing our work on the task committee.

The key words are that the Foundation is authorized and directed to initiate and support basic scientific research and programs to strengthen the mathematical, physical, medical, biological, scientific research potential and science education programs at all levels.

In its authorization, it has a very broad charge. The point that you are making, of course, is a very key one. How do you define within that broad charge what the priorities should be? It boils down, I think, to there are some short term issues and some long term issues. These very individuals requiring the shoes; there will be more of them requiring shoes, if we lose our competitive edge. Our falling behind in the advanced microprocessors' area, which people in Silicon Valley know quite a bit about, has cost this country in its trade deficit, billions of dollars. If you trace that back, that is probably hundreds and thousands of jobs lost.

Mr. **Mineta**. Well, if NAS, National Academy of Sciences, has said that the loss of jobs is 198,000 and the loss of export trade was *$9.3 billion. You are right.*

Dr. **Neal**. Yes, and so, that winds its way back to affect even the resources that Congress has to allocate for education, for help to the poor and to everyone. It's a very tightly coupled——

Mr. **Mineta**. Let me go to the next step. Within NSF, are the priorities right? I mean, is it SEE or do we go to the other—should we be spreading the money throughout the various directorates in terms of what monies are available?

Dr. **Neal**. Of course, it's a very complex issue. If you get three or four or five very intelligent people together and asked them that question, it's very easy to get different answers.

Certainly I have implied my own views about this. I think that the $60 million or so that we are spending in support of undergraduate education is just much too little for a country such as ours. One could do all types of analyses to try to convince yourself what the appropriate figure should be, and I've done that to satisfy myself. All the answers I get is something much larger, but not infinite. I mean, it's not—there is a level beyond which I would advise the Foundation not to go, but $60 million is just too little.

Dr. **Straumanis**. I just wanted to make one comment. I think that depression is an appropriate response to the problem of the homeless and so on. That is a very expensive problem to address. But, depression is not the appropriate response to what we are talking about here, because this is something that can be addressed and effectively at relatively low levels of funding. The funding levels that we are talking about are not enormous. They are not as Dr. Neal said, infinite, and we can make a great deal of progress with the first few million of these dollars.

So, I think there is reason for some optimism here. We will see improvement, I think, with our first few years of investment.

Mr. **Aldridge**. May I comment? You are asking really what NSF should do and they have been told what to do by you. It's in the statutory authority for the Foundation.

If you look at our testimony and look at the statutory authority, you will find that the Foundation is refusing to do what you have told them to do. If they did the things which were outlined in the authority that you voted, that is, this Congress, they would be doing the things that we think are important. The question it seems to me is how do you get the Foundation to do what you have told them to do? It certainly is not reflected in the budget and I specifically point out in the written testimony, the areas in which they failed, and you can compare that with the proposed budget, and see that they have totally ignored programs which you specifically asked them to incorporate, and it's in the testimony.

Mr. **Mineta**. If I could then ask you, the panelists, to do me a favor, to do the Committee and the Congress a favor. There is a requirement for that five year strategic plan which is due on the 30th of November of each year. It was due November 30, 1986. We got it on the 17th of February. I know you haven't had a chance to take a look at it.

I am wondering if I could ask each of you to take a look at that, critique that, and submit to the Committee your recommendations and analyses of that annual report that was due on the 30th of November.

Mr. **Aldridge**. If we can get a copy.

Mr. **Mineta**. I'm quite sure we would be able to make copies available to the very distinguished panel. Thank you very much, Mr. Chairman. Thank you very much.

Mr. **Walgren**. Thank you, Mr. Mineta. The gentleman from Kentucky, Mr. Perkins.

Mr. **Perkins**. Let's see; does this work? No, I don't need it anyway. I'm not going to talk too much. I apologize for being late. I was at Education and Labor. We had Secretary Brock attempting to deal with some of the issues of the unemployed in America today and some of those proposals are forthcoming from the Administration.

At this time, you know, one of the problems that I really believe we have in developing future scientists on a nationwide basis, is a lack of an adequate science program in the elementary and secondary schools. In November, I had occasion to meet with a number of guidance counselors in my area for all Eastern Kentucky. At that time, they went about telling me about the great difficulty they were having in finding the adequate science teacher or finding a science teacher.

I heard the lady here from Rollins talking about the 60 percent foreign nationals that were the best qualified people. We don't have any applicants at all for these jobs at the elementary and secondary level; that is in fact even restricting them from being accepted to colleges that require two years of science to get in.

It appears to me that as long as we have this problem, this kind of an across the board, from what I can tell in talking to a number of people, on a nationwide basis, that we need to develop some sort of program that would begin to kind of address this fundamental need, as I perceive it.

Is there anything that—you know. I know it is the allocation of the resources that are apparently going to the undergraduate programs. I can understand why you are doing that, but post-secondary and elementary, I mean, we have to get there. Don't you think that we need some sort of developmental program on the part of the NSF to deal with the situation?

Mr. **Aldridge**. You are talking now about programs for in-service or pre-service for science teachers and mathematics teachers?

Mr. **Perkins**. Yes.

Mr. **Aldridge**. Yes, of course. There are programs in the Foundation now which address that. They simply are inadequately funded. If they are very serious about that and the fact that 30 percent of all of the children in high schools in the United States today are being taught by unqualified science and math teachers——

Mr. **Perkins**. I would think it would be higher than that.

Mr. **Aldridge**. It's about 30. Most of the studies show that figure. The fact that exists, that problem exists, and is not being adequately addressed is very serious.

You came from a hearing where you already know that the President is proposing to eliminate the Title II funds, $80 million of science and math block grant money, for teacher in-service programs in science and mathematics education. So, we have not only the flat funding in NSF, but an $80 million cut in the Department of Education being proposed. The problem is not being addressed at all.

Mr. **Perkins**. I am going to quit. I am going to share Norm's view here. It's depressing listening to this.

Mr. **Walgren**. Well, you know, I can't help but have the feeling that we are in some kind of a box and the problem—the charter of the National Science Foundation is so fundamental. Its development has been so limited in many ways because of some of the things we do in other parts of the Government. You cannot help but be literally stunned by the size of the increases in other kinds of research, particularly military research. These budgets that have come up here, military has a net increase on a year to year basis, in their research and development function of something in the range of $5 billion, and the total effort in the National Science Foundation is $1.2, $1.3, $1.4 billion during that period of time. It is awful hard to know how to address those kinds of imbalances when you are starting from such a low level.

Dr. Neal, you said you had worked out some appropriate levels, you felt, of effort in these areas, and that there were some specifics behind that and even a range where you could recommend it probably would not be right to go. Can you develop that for us? Was it done with—let me give you just my shorthand here.

Generally, in the 1960's, science and education was 30 percent of the NSF budget. If the budget goes as the Administration recommends and it expands to something like $3 billion in 1992, that means we should be looking at, if we were giving the 1960 decade emphasis, to the Directorate of Science and Engineering Education, we would be looking at about $1 billion in science engineering education direct funding.

We are looking to add $100 million to $115 million at this point, so we would be, current scenarios, running $200 million plus, maybe we get to $250 million or something like that, under present balances.

When you contrast those two differences, you got to realize, we have to break out of this box someplace, if that previous estimate is the right balance.

Dr. **Neal**. Some of you up here are trying to estimate what an appropriate NSF role would be in addressing the undergraduate problem. One could be the historical analysis that you've just mentioned.

I think in a time not very long ago the contributions to undergraduate programs through the NSF budget were of the order of $100 million in today's dollars. We are now dealing with something that is much less. That is a flag that there is something wrong.

One could look at the education of our students as an industry. It's another analysis; it's a dangerous one, but it appears that it costs on the average about $4,200 per undergraduate student. That's what the educational cost is per year. The NSF budget spread out over our undergraduate students is about $6.00 or so, I think, per student.

You could ask yourself if you had an industry how much effort should you be investing in R&D to make sure that whatever this product is that you were generating gets better and that your delivery of instruction in this case is improved. That's less than, I think, a tenth of a percent and that is not right. There's something wrong there.

The other approach, of course, is to go to the output end. You ask each—you talk to Deans and Provosts and Departmental Chairs to find out what is the state of their undergraduate curriculum, what is the state of their laboratories, what would be required to restore them to a level that would be appropriate. You can then come up with another sum.

The point I wanted to make is that when I approach the problem from all of these points of view it is very clear that the $60 million is much too little.

There's another big element here, and that's the leveraging factor. I think we've consistently said that the NSF should not be expected to cover all these costs. That would be inappropriate. But we need to participate at a sufficiently high level to be able to properly be viewed as being in a leadership position. I think at least for a while there was progress in the pre-college area because there were commission studies, the calling of attention to the terrible situation. One of the things that happened, of course—one of the things that occurred as a result of that is that many states formed their own commissions, legislative bodies got interested. Now you see a lot more activity at a state level. As a result, I think of those efforts.

So, leveraging is a very important part and that has to enter the equation before you could really determine how much support the NSF should be giving.

Mr. **Walgren**. You mentioned that there was a figure that you felt was beyond what could usefully be spent, and I'm wondering what that is.

Dr. **Neal**. I am advised by counsel. [Laughter.]

Mr. **Walgren**. Well, I think your words and your testimony, if I'm remembering right, essentially that we should be ashamed of levels of effort of the kind that we have had in recent past, and one of the real obligations of an authorizing committee is to lay out the "shoulds," what should happen. We all realize we're in—you know, there are other limits on us. But our first obligation is to lay out what should happen.

Dr. **Neal**. I understand. My only concern is that my estimate as to what upper limits should be has not been worked out with the care that would be required before I would mention a number in an open session of this nature.

On the record is our recommendation that by FY89 there be at least an increment of $100 million. I can tell you that we arrived at that figure being somewhat conscious of the fact that it was very unlikely if the NSF budget kept going up, as you just mentioned, from $1.2, $1.3, $1.4 billion—it should be very unlikely that undergraduate education could claim much more than that.

But I think now the entire—it's a new ballgame, in a sense. If in fact the NSF budget is going to grow by significant amounts in the next few years, I think one of the things the NSF should do almost immediately is to have this question raised as part of its planning process. What does it see as a five-year plan for undergraduate education, or science education in general.

I think that if it goes about that, involving the proper cross-section of consultants from academia, its own advisory councils and what have you, that a number could be arrived at that would have the collective wisdom of several people. But I would be very hesitant to offer what a limit should be except, on the basis of what I've already said. It's clear that it's a number that is significantly larger than $100 million.

Mr. WALGREN. I see. Mr. Chapman.

Mr. CHAPMAN. Let me ask just a general question of the panel on something that came up back in Texas a week or so ago.

From the standpoint of your hands-on dealing with students, perhaps moving through this plan, how much incentive and how helpful would it be if we developed some type of program that would either forgive or further postpone the further repayment of college loans with the students entering the teaching profession?

Based on your experience of college students and undergraduates now moving through the pipeline, would that be a worthwhile area perhaps to explore as an incentive to get these folks into jobs that otherwise might not look as attractive? Would it be helpful?

Mr. ALDRIDGE. If you had proposed that two years ago, I would have hesitated. There is some evidence that people prepared to teach through that means have gone out and found that there were no teaching jobs because tenured, unqualified teachers were being moved into those slots instead of hiring new employees.

However, there is sort of a catastrophe coming down the road in 1992 in terms of people in the age group of 18 to 24 and we're going to have a great need for science and math teachers, and every other type of personnel, in that period beginning in 1992. We'd better start now if we're going to prepare them.

So, I would say yes, that such programs—and they do exist already. I have information on the other states that have such programs and would be happy to provide that to you if you would like to see it.

Dr. STRAUMANIS. My own experience with the program I described to you for the five-year teacher preparation plan definitely would benefit from such an arrangement. The number one problem for the administrators of that program is funding the students who want to get into the program.

Mr. WALGREN. Mr. Chapman.

Mr. CHAPMAN. Thank you, Mr. Chairman.

Mr. WALGREN. I wanted to give you an opportunity to underscore your testimony about the importance administratively of the Science and Engineering Education Directorate as the administrative focus for this responsibility. I really can only express concern that when these monies are over in other efforts that they get lost in a shell game and perhaps become much more vulnerable to the kind of diversion or occupation of that resource by a strong constituency within these other areas.

Should we be comfortable hearing the National Science Foundation tell us we're spending $268 million on science and engineering education when the line item for the Science and Engineering Education Directorate is $115 million?

First to Dr. Neal because it was your testimony that focused on that.

Dr. **Neal**. Yes. It's a complicated issue. One of the things that one wishes to do is to involve research scientists and engineers in helping with the education process. The argument has been made that to forge this link one should use the research directorates as much as possible.

I am not so much as bothered by how the money gets spent as the absence of an administrative oversight for undergraduate education now. Namely, there is not a single—there's not an office or division, as was mentioned, explicitly charged with oversight of undergraduate education. Who knows where the money comes in, where it goes out, and can make an assessment as to whether or not it's an effective use of the funds.

So, I think members of the panel may have varying views as to precisely how the funds would be managed, where everything should go and be expended directly out of the SEE Directorate or some of it going through the Research Directorates.

But if you're going to use many different channels for expending the money, there at least should be one individual, one office charged with ultimately keeping track of what's going on, evaluating it and making recommendations for improvement in the future.

Dr. **Straumanis**. We think it's not inappropriate for the research directorates to have a good deal to say even about the quality of the research that goes on at undergraduate institutions. That is, the research that the faculty do. It does seem to me that that could well reside in the research directorates, but what we need is the accounting, the advertising, the publication, and all of that being in the Science and Engineering Education Directorate so that there is communication between the two directorates on that score.

We also think that it's very important that the peer review process that involves those undergraduate science faculty research proposals be overseen or at least investigated from time to time by those who have a special interest in undergraduate science education. Those would be within a special division in the Science and Engineering Education Directorate.

I don't see any problem with interdirectorate cooperation on some of these points. We would like to see a focus of responsibility in the Science Education Directorate.

Mr. **Aldridge**. I think the best answer to your question is to look at what happened to $5 million that was transferred over to the research directorates of Science and Education about three years ago for purposes of research and learning. If you look for that now, you'll find it no longer exists. It's been dissipated within that research division and that directorate to the point that it doesn't even show up in the budget anymore. That's what happens when you don't have adequate accountability.

Now, the Science and Engineering Education Directorate at NSF has among its staff people who are equally qualified in science, engineering and in education. These are generally Ph.D's in a subject field. These are not wild-eyed educationists running around over there. These are scientists themselves who have done research. They are as well qualified as the research directorate personnel.

If you want to have additional personnel or identifiable people to administer those programs, hire some new ones in a unit—in a higher education or an undergraduate unit within the Science Education Directorate. It makes no sense whatsoever to have those programs in the research directorates except as a device to obscure what the true purpose of the programs are, and that's simply to make it look like you're doing something in science education when in fact you're simply supporting further efforts toward the research activity.

Mr. **Walgren**. Let me also ask the general question about the balance between the Department of Education as the entity for science education as opposed to the National Science Foundation. I think you talked about that in your testimony, Dr. Neal. It is an ongoing battle here because, of course, we have constituents in both camps, people who are interested in both agencies.

Dr. **Neal**. My vision of the appropriate arrangement would be to have the National Science Foundation to be the agency that is charged with the support of science and engineering education in that it would fund—well, there is a list of things that I would like for it to do—but that it would fund those activities at an appropriate level and would demonstrate a deep commitment to those programs.

As I indicated in my testimony, I'm very hopeful that this $38 million response to the undergraduate report, if that is coupled with a significant level of funding for science education in its five-year program, then I would see very little reason to consider even moving the programs.

The NSF does have a very enormous network with faculty members in a variety of types of colleges and universities across the country, large advisory network. Many of these people are precisely the ones that you want to get involved in science education. So this appears to be the natural agency to do this, and it marries, at the federal level, the research and teaching missions that exist at the campus level where faculty members do research and teach.

What I think is wanted is for us to discharge those two functions in the best possible way. You would think that dealing through an agency like the NSF would be the best place to do it.

Dr. **Straumanis**. Movement of some of these programs to the Department of Education would also break up what is obviously a natural community of interest. You see here three people from three different kinds of institutions within the whole science education community and we are in accord about this. It seems as if whatever one of us does affects the other two.

Mr. **Walgren**. Well, let me then also underscore the question that Mr. Mineta asked of you, and that is that you give us a disciplined critique of the strategic five year plan that we now apparently are all just getting and get that to us with some discipline, because we would like to have that for this record and we would like to have it before we authorize this Agency for another year, because we would like that perspective that you have. [See Appendices 2 and 3].

Mr. **Walgren**. On behalf of the Committee, let me thank you for your presentations and your ongoing contribution. We look forward to continuing that with you. Thank you very much.

[Whereupon, at 12:22 p.m., the Subcommittee was adjourned, to reconvene at the call of the Chair.]

1988 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

WEDNESDAY, FEBRUARY 25, 1987

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Science, Research and Technology,
Washington, DC.

The Subcommittee met, pursuant to notice, at 9:40 a.m., in room 2318, Rayburn House Office Building, the Honorable Doug Walgren (chairman of the Subcommittee) presiding.

Staff present: James Wilson; David Goldston.

Mr. Walgren. Gentlemen, welcome to the Committee. Please join us at the table there.

This is the second hearing on the National Science Foundation's authorization for this coming fiscal year, 1988. We have separate panels this morning addressing the impact of the Administration's NSF budget on programs and initiatives affecting on the one hand, advanced scientific computing, the relationships between the National Science Foundation and industry, and the balance between funding for multi-investigator centers versus distributing support for individual investigator grants.

We had a previous hearing on the 19th, which focused on science and engineering education at the pre-college and undergraduate levels.

We are pleased to have as witnesses this morning and welcome to the first panel, Dr. William Lester. Good morning, Dr. Lester. Dr. Lester is Professor of Chemistry at the University of California, Berkeley, and Chairman of the Advisory Panel for the National Science Foundation's Division of Advanced Scientific Computing.

We also have Dr. Robert Sugar, Professor of Physics at the University of California, Santa Barbara, and Michael Roberts, the Acting President of EDUCOM.

The National Science Foundation has begun an initiative to meet identified national requirements in advanced scientific computing. The goals are to provide university researchers with access to the most powerful scientific computers, to train a new generation of scientists and engineers in research related to those computers, and to encourage the development of more advanced scientific computing and new techniques for their use.

The national supercomputers centers established by NSF will play a central role in the development of these goals. We look forward to hearing comments on this area from this panel.

We will then have a second panel made up of Dr. Paul Gray, the President of the Massachusetts Institute of Technology and Mr. Richard Case, Vice President for University Relations at IBM. That panel will focus on improved industrial competitiveness and the challenges that we face in that area.

The National Science Foundation has started initiatives to create links between university research and industrial technology in order to develop research problems relevant to improving manufacturing technologies. This panel will address the appropriateness of the Science Foundation's growing relationship with industry and the effectiveness of those programs.

Then we will have a final panel this morning made up of Dr. Harold Shapiro, President, University of Michigan; Dr. Sheila Widnall, representing the American Association for the Advancement of Science and a Professor of Aeronautical Engineering at MIT; and Dr. Joseph Goldstein, Vice President for Research at Lehigh University. That panel will discuss the issues of balancing the National Science Foundation's funding between the research centers on the one hand and the individual investigator grants on the other.

Clearly, in order to encourage multi-disciplinary approaches to new research problems, we must group research together. The National Science Foundation has encouraged the establishment of research centers, typically comprised of faculty members from several traditional separate departments, but there is the concern that the health of the underlying central programs which have been the source of support for a wide variety of individual investigations may be undercut in providing the funding needed to establish significant numbers of centers, and there is a balance there that we want to explore.

[The prepared opening statement of Mr. Walgren follows:]

OPENING STATEMENT OF HON. DOUG WALGREN (D-PA), NATIONAL SCIENCE FOUNDATION AUTHORIZATION, FEBRUARY 25, 1987

This is the second hearing on the National Science Foundation's (NSF) Authorization for Fiscal Year 1988. We will have separate panels this morning addressing the impact of the proposed NSF budget on programs and initiatives affecting advanced scientific computing, NSF/industry interactions, and the balance between funding for multi- investigator centers versus individual investigator grants. A previous hearing on February 19, 1987 focused on issues concerning the important subject of science, mathematics and engineering education at the precollege and undergraduate levels.

We are pleased to have as witnesses and welcome to the first panel Dr. William Lester, Jr., Professor of Chemistry at the University of California-Berkeley and Chairman of the Advisory Panel for the NSF Division of Advanced Scientific Computing; Dr. Robert L. Sugar, Professor of Physics at the University of California-Santa Barbara; and Mr. Michael M. Roberts, Acting President of EDUCOM.

NSF has begun an initiative to meet identified national requirements in the area of advanced scientific computing. The goals are to provide university researchers with access to the most powerful scientific computers, to train a new generation of scientists and engineers to use supercomputers, and to stimulate the development of more advanced scientific computers and new techniques for using supercomputers. The national Supercomputer Centers established by NSF will play a central role in the attempt to meet these goals. We are looking forward to hearing from this distinguished witnesses on the effectiveness of the current activities of NSF and the likely impact of planned initiatives.

To the second panel, we welcome Dr. Paul Gray, President of the Masachusetts Institute of Technology; and Mr. Richard Case, Vice President for University Relations at IBM.

Improved industrial competitiveness has been recognized as a key to meeting the challenges of an increasingly international marketplace. NSF has started initiatives to forge links between the University Research Community and the Industrial Technology Community in order to identify and attack research problems relevant to improving manufacturing technologies. This panel will discuss the appropriateness of NSF's growing relationship with industry and the effectiveness of the programs being pursued.

To the final panel, we welcome Dr. Harold T. Shapiro, President of the University of Michigan; Dr. Shelia E. Widnall, President of the American Association for the Advancement of Science and Professor of Aeronautical Engineering at MIT; and Dr. Joseph Goldstein, Vice President for Research of Lehigh University.

The distinguished members of this final panel will discuss the issue of balancing NSF funding between multi-investigator research centers and individual investigator grants. In order to encourage multi-disciplinary approaches to new research problems residing at interfaces between disciplines, NSF has encouraged the establishment of research centers typically comprised of faculty members drawn from several traditional departments. However, there is the concern that the health of the core programs, which tend to be single investigator grants, may be jeopardized in providing the funding needed to establish significant numbers of centers. Therefore, it is important to consider what principles should be applied to ensure that the correct funding balance is maintained.

Mr. WALGREN. Well, with that as introduction, let me turn first to the ranking minority member, Congressman Boehlert, from New York, for an opening statement.

Mr. BOEHLERT. Thank you very much, Mr. Chairman.

This morning's hearing should be viewed as part of the debate on competitiveness that is consuming this town these days. So far, much of the debate has resembled nothing so much as the old Groucho Marx's game show, "You Bet Your Life". Partisans for every cause feel all they have to do is say the secret word, "competitiveness," and they can collect $100. It's something we see around the House every day.

I think today's hearing will prove more constructive. We are not merely going to assert that the National Science Foundation makes a vital contribution to competitiveness. We are going to get a clear sense of what that contribution is and how it can be augmented.

There are really two basic questions before us this morning. How can we ensure that our research enterprise remains the envy of the world, and how can we translate that academic advantage into economic success?

Take the questions raised by the supercomputer centers, for example, an initiative that I helped father, and one that must be continued. How do we enable our scientists to continue to have access to the most advanced computing equipment available? How do we compete with the Japanese effort to overcome our advantage in the supercomputer market? Should National Science Foundation support ever go to help purchase a foreign supercomputer?

Each panel this morning will be asked to grapple with these questions and others equally perplexing. We will use their answers to build support for a National Science Foundation budget that will not only grow, but will grow in a balanced way; one that will support research without slighting education, that will provide a solid foundation for industry without slighting academia, that will establish centers without slighting individual researchers.

Our task is difficult, but we have invited some of the best minds in the country to help us, and I look forward to their testimony.

[The prepared opening statement of Mr. Boehlert follows:]

OPENING STATEMENT OF CONGRESSMAN SHERWOOD BOEHLERT (R-NY), NATIONAL SCIENCE FOUNDATION AUTHORIZATION FOR FY 1988, FEBRUARY 25, 1987

Mr. Chairman: This morning's hearing should be viewed as part of the debate on competitiveness that is consuming this town these days.

So far, much of the debate has resembled nothing so much as the old Groucho Marx game show, "You Bet Your Life." Partisans for every cause feel that all they have to do is "Say the secret word"—competitiveness—and they can "collect a hundred dollars": It's something we see around the house every day.

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There are really two basic questions before us this morning: How can we ensure that our research enterprise remains the envy of the world, and how can we translate that academic advantage into economic success?

Take the questions raised by the supercomputer centers, for example, an initiative that I helped father—and one that must be continued. How do we enable our scientists to continue to have access to the most advanced computing equipment available? How do we compete with the Japanese effort to overcome our advantage in the supercomputer market? Should National Science Foundation support ever go to help purchase a foreign supercomputer?

Each panel this morning will be asked to grapple with questions as perplexing as these. We will use their answers to build support for a National Science Foundation budget that will not only grow, but will grow in a balanced way—one that will support research without slighting education, that will provide a solid foundation for industry without slighting academia, that will establish centres without slighting individual researchers.

Our task is difficult, but we have invited some of the best minds in the country to help us. I look forward to their testimony.

Thank you.

Mr. WALGREN. Thank you, Mr. Boehlert. Are there any other members who would like to make opening comments at this time?

[No response.]

Mr. WALGREN. Let me then say at the outset that we, as we have talked with you individually, feel that we have to hold to a very strict eight minute limit on presentations. I apologize for that because there is so much we would like to go into, but with a witness list this long and the number of members that may cycle through here, it is really the proper way to proceed. It will make each of your contributions to the record more meaningful in the overall.

With that as a thought at the outset, I have a timer here and we will sort of use it, and certainly if you get to that point and need a little bit more time to conclude, you will have that, but if you would be very mindful of that, we would appreciate it.

I can't help but be reminded, thinking of the magic word, my little four year old was not asking right for someone to pass him something at the dinner table and his six year old brother said, say the magic word. He said, abracadabra. It wasn't the right word. For him, it was the magic word.

Let's turn to the first panel and we will go in the order we introduced you and we will start with Dr. Lester and then go to Dr. Sugar and then to Mr. Roberts.

Dr. Lester.

STATEMENTS OF DR. WILLIAM A. LESTER, JR., CHAIRMAN, ADVISORY PANEL FOR THE DIVISION OF ADVANCED SCIENTIFIC COMPUTING, NSF, AND UNIVERSITY OF CALIFORNIA-BERKELEY; DR. ROBERT L. SUGAR, PROFESSOR, DEPARTMENT OF PHYSICS, UNIVERSITY OF CALIFORNIA-SANTA BARBARA; AND MR. MICHAEL M. ROBERTS, ACTING PRESIDENT, EDUCOM, PRINCETON, NJ

Dr. LESTER. I'd like to begin by briefly summarizing the remarks contained in the material I made available.

Mr. Chairman, and Honorable Members of the Committee, it is a pleasure for me to be here today, to testify on the FY 1988 budget proposal for advanced scientific computing of the National Science Foundation. My perspective is an outgrowth of membership since 1985 on the Program Advisory Committee of the office responsible for supercomputing, which is now the Division of Advanced Scientific Computing, and service as Chairman (in 1986) of the Centers, Supercomputer Centers Subcommittee of the Program Advisory Committee. I am the current Chairman of the PAC.

The NSF initiative in advanced scientific computing was started in FY 1984, and I mention this to emphasize that supercomputer centers are new and not at all mature. They are in a growth phase, that must be nurtured to have them reach the potential envisaged in the planning leading to their creation.

The cooperative agreements that were developed for the centers contained funding levels that have not been maintained for a variety of reasons. It is not my intention to discuss these, but to call attention to the fact that funds expected on the basis of agreements, have not been fulfilled and that as a consequence, various aspects of different center's programs have had to grow more slowly.

A critical issue for the continued development and role of the centers, if they are to have a unique role in the development of supercomputing in this country, is that they be maintained at the cutting edge of technology. In their brief history, none of the centers has as yet attained that status. It is important that the budgets for the coming year, and successive years be established at least at the levels presented in the cooperative agreements, and that previous unfulfilled commitments be met.

Although we are in a period of budget constraint, it is essential that centers be maintained at the state of the art. I refer here not only to hardware, but to software, network access, graphics, consulting and other support activities. In the last year, a few major universities and states have purchased their own supercomputers, and in this climate, where it is expected that some number of other institutions will follow, the unique mission of the NSF centers must be maintained, or we shall see them dwindle, and not be significantly different from the State and university centers under development.

If the centers are forced to seek funds from industry to maintain essential aspects of their mission, then the long range implications are bleak. Although industrial involvement at a significant financial level was a much-discussed avenue for increased funding in the planning stage of the centers, it has not been adequate to offset funds expected based on the cooperative agreements that have not been provided.

The distribution of funds among support for supercomputer cycles, networking activities, and computer science research relevant to improved utilization of supercomputers has been a matter of much discussion for the PAC. Because of budget reductions, and associated slowing of implementation of development plans, all of these areas have been affected. Priority has been placed on establishing the supercomputer facilities, and remote access to them (networking capability) with the consequence that computer science research related to supercomputer use has, in general, received less attention.

In late 1986, the Assistant Director for Computer Information Science and Engineering split the Office of Advanced Scientific Computing into two divisions. One is concerned with supercomputing (that is the Division of Advanced Scientific Computing) and the other with networking (the Division of Networking and Communication Research and Infrastructure).

This step called attention to the importance of networking for users scattered across the nation, but it also raised concerns among some Program Advisory Committee members, that networking support for supercomputing could receive lower priority. The Program Advisory Committee has been assured that at least in the near term, supercomputing would retain the highest priority. This response from the Networking Division recognizes the possibility that there may arise other national needs that might compete with supercomputer access.

The National Science Foundation centers have responded remarkably well to the requirement of providing university researchers, undergraduates and graduate students, with access and education in the use of the most powerful scientific computers available. One measure of the success of the supercomputer program in its short period of existence, is the use of centers by scientists who have not engaged previously in large-scale calculations. There are leading scientists whose research approaches are focused on analytical techniques, or on experimental methods, that have turned to the use of computer simulation, and obtained fundamental new insights.

In at least two instances at my university, the University of California, Berkeley, I have seen this phenomenon occur. Further, the implementation of these computational approaches is often carried out by graduate students. This is a common way in which graduate students acquire knowledge in the use of supercomputers.

And now with the time I have remaining, I'd like to introduce aspects of a statement put together by the various center directors, which I think very concretely summarizes some of the key dimensions related to those centers.

The national centers have acquired, installed and are operating their supercomputer systems, and have obtained staff for management operation, networking, provision of user services, and new projects such as visualization. The centers are fully operative. Some centers are already saturated, and total usage has been growing rapidly.

In the brief two year period, researchers in all scientific and engineering disciplines have gained access to a wide range of advanced computing capabilities. Centers have been successful at attracting non-NSF support to help in these efforts. This includes donations of computer systems and workstations from the computer industry, corporate support for industry, university, and collaborative research, State and university support for networking and communications, work space for staff, renovations and new structures, and industry discounts on equipment and software.

Now with regards to the future, the best and proper role of the centers in the future is the key issue in establishing plans and budgets. In December, in 1986, the directors of the six NSF centers, including the National Center for Atmospheric Research, met to discuss future directions and the resulting program needs. The directors agreed upon the following goal for the national centers, and I quote: "To advance science in engineering as far as the cutting edge of computational technology will allow."

Now the centers have created an intellectual and computational environment that encourages bold attacks on important problems. They are now attracting researchers at universities and industry to collaborate on interdisciplinary problems of a national scope, and with common computational needs.

To fully realize the potential of the centers, there must be substantial, long-term support at the national level, for the maintenance of a broad intellectual and computational environment. They see emerging several examples of very significant national and interdisciplinary problems, which they refer to as grand challenges. Some of these include, and I won't elaborate on these because of the time limitation, the general area of electronic structure, aspects of molecular biology—in terms of macromolecular structures, global geosciences, complex problems that govern the biosphere, computational fluid dynamics—unravelling the fundamental basis for the flow of matter. In particular, the latter studies can advance understanding, for example, of oil reservoir dynamics, ocean surface wave interaction, and so forth. Decoding genomes is another one of these grand challenges. Brain mapping and modelling the global economy are others.

The role of the centers in these grand challenges is as follows: The center directors find that there is some common prerequisites for achieving full benefits of supercomputers in these grand challenges.

First, each of these needs a fully interacting computational community from a wide range of disciplines to ensure that the best algorithmic scientific approaches are identified and pursued.

Second, each needs continually evolving facilities, at the cutting edge in capabilities and performance, to ensure the best use of algorithms and timely solution of problems.

The key roles that the center directors see for the centers in addressing the grand challenges are: First, they provide a concentration of technical and computational expertise, capable of supporting these projects. Second, they provide major resources at the leading edge of computational technology that have to be centralized for maximum capability and performance because their cost is, and will remain, beyond the reach of most universities. Third, they provide a flow of information between various computational communities solving these problems—avoiding duplication of effort and speeding the widespread use of new information and computational techniques. Fourth, they interact with industry through collaborative research, training, and the communications inherent in the U.S. scientific community in productive ways that enhance technology transfer.

There are many applications of supercomputers that require the full range of human and technological resources of a national center. The centers will have a critical role in initiating new scientific and engineering applications and will transfer these technologies to the industrial and university computational science and engineering communities. This will contribute to the strengthened United States competitiveness in the world marketplace.

As I see that time is limited, I want to turn to my final summarizing statement, Mr. Chairman. It is essential that the centers receive the funding planned in the cooperative agreements. To not do so will severely limit, if not eliminate, the possibilities envisaged in the creation of the supercomputer initiative.

Further, the centers have made excellent progress, but they are still in a growth phase. If they are to reach and maintain the capability originally contemplated, it is essential that adequate resources be provided so that they are maintained at the state of the art in hardware, software, network access, graphics and associated areas.

Thank you very much.

Mr. WALKER. Thank you very much, Dr. Lester. We appreciate that statement, and let's turn to Dr. Sugar.

[The prepared statement of Dr. William A. Lester, Jr. follows:]

Testimony of William A. Lester, Jr.

before the

Subcommittee on Science, Research and Technology

of the

Committee on Science, Space, and Technology

U. S. House of Representatives

Mr. Chairman and Honorable Members of the Committee, it is a pleasure for me to be here today to testify on the FY1988 budget proposal for advanced scientific computing of the National Science Foundation (NSF). My perspective is an outgrowth of membership on the Program Advisory Committee of the former NSF Office of Advanced Scientific Computing, now the Division of Advanced Scientific Computing since 1985 and service as Chairman of the Centers (supercomputer centers) Subcommittee of the PAC in 1986. I am the current Chairman of the PAC.

Background

The NSF initiative in advanced scientific computing was started in FY1984, and I mention this to emphasize that the supercomputer centers are new and not at all mature. They are in a growth phase that must be nurtured to have them reach the potential envisaged in the planning leading to their creation. The cooperative agreements that were developed for the centers contained funding levels that have not been maintained for a variety of reasons. It is not my intention to discuss these but to call attention to the fact that funds expected on the basis of agreements have not been fulfilled and that as a consequence various aspects of different center's programs have had to grow more slowly.

A critical issue for the continued development and role of the centers, if they are to have a unique role in the development of supercomputing in this country, is that they be maintained at the cutting edge of technology. In their brief history, none of the centers has attained that status. It is important that the budgets for the coming year and successive years be established at least at the levels presented in the cooperative agreements and that previous unfulfilled commitments be met.

Adequacy of Overall Budgets Proposed for Advanced Scientific Computing

Although we are in a period of budget constaint, it is essential that the centers be maintained at the state-of-the-art. I refer here not only to hardware but to software, network access, graphics, consulting and other support activities. In the last year, a few major universities and states have purchased their own supercomputers and in this climate, where it is expected that some number of other institutions will follow, the unique mission of the NSF centers must be maintained or we shall see them dwindle and not be significantly different from the state and university centers under development.

If the centers are forced to seek funds from industry to maintain essential aspects of their mission, then the long-range implications are bleak. Although industrial involvement at a significant financial level was a much-discussed avenue for increased funding in the planning stage of the centers, it has not been adequate to offset funds expected based on the cooperative agreements that have not been provided.

The distribution of funds among support for supercomputer cycles, networking activities, and computer science research relevant to improved utilization of supercomputers has been a matter of much discussion for the PAC. Because of budget reductions and associated slowing of implementation of development plans, all of these areas have been affected. Priority has been placed on establishing the supercomputer facilities and remote access to them (networking capability) with the consequence that computer science research related to supercomputer use has, in general, received less attention.

In late 1986 the Assistant Director for Computer Information Science and Engineering split the Office of Advanced Scientific Computer into two divisions. One is concerned with supercomputing (Division of Advanced Scientific Computing) and the other with networking (Division of Networking and Communication Research and Infrastructure). This step called attention to the importance of networking for users scattered across the nation, but also raised concerns among some PAC members that networking support for supercomputing could receive lower priority. The PAC has been assured that at least in the near term, supercomputing would retain the highest priority. This response recognizes the possibility that there may arise other national needs that might compete with supercomputer access.

I would now like to return to the issue of supercomputer cycles. A focus on cycles can miss the important distinction between computer capability and computer capacity. I use these two terms to distinguish, on the one hand, the power (capacity) of a computer to produce results on a time scale that is practical for the completion of a project. This consideration can often dictate whether a project is undertaken. This situation is to be contrasted with capacity, in the restricted sense used here, which relates solely to the number of cycles. In brief the focus of the supercomputer initiative is to provide maximum capability. Capacity comes as a byproduct of the capability of the supercomputers to provide high speed and large memory access enabling the treatment of research problems that could not otherwise be addressed.

The NSF centers have responded remarkably well to the requirement of providing university researchers with access to the most powerful scientific computers available, i.e., Cray X-MP, Cray 2, Cyber 205, IBM 3090-400, and shortly ETA-10. One measure of the success of the supercomputer program in its short period of existence is the use of the centers by scientists who have not engaged previously in large-scale calculations. There are leading scientists whose research approaches are focused on analytical techniques or on experimental methods that have turned to the use of computer simulation and obtained fundamental new insights. In at least two instances at my university, the University of California, Berkeley, I have seen this phenomenon occur. Further, the implementation of these computational approaches is often carried out by graduate students. This is a common way in which graduate students acquire knowledge in the use of supercomputers.

Additional insight on issues that the PAC has been concerned with recently contained in the summary of a recent meeting of a PAC subgroup with Dr. Gordon Bell, Assistant Director, Computer and Information Science and Engineering at NSF. The letter of the meeting is attached as an appendix.

To summarize Mr. Chairman, it is essential that the centers receive the funding planned in the cooperative agreements. To not do so will severely limit, if not eliminate, the possibilities envisaged in the creation of the supercomputer initiative. Further, the centers have made excellent progress but they are still in a growth phase. It they are to reach and maintain the capability originally contemplated, it is essential that adequate resources be provided so that they are maintained at the state-of-the-art in hardware, software, network access, graphics, and associated areas.

Appendix

Testimony of William A. Lester, Jr.

UNIVERSITY OF CALIFORNIA, BERKELEY

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DEPARTMENT OF CHEMISTRY BERKELEY, CALIFORNIA 94720

February 3, 1987

WAL: 87-137

Dr. Gordon Bell, Assistant Director
Computer and Information Science and Engineering
National Science Foundation
1800 G Street, N. W., Room 306
Washington, D. C. 20550

Dear Gordon:

I am pleased that we had the opportunity to meet with you on January 12th to discuss your recent communications (letter to PAC of October 23, 1986, letter to Center Directors of August 29, 1986, and "Preparing for Changing Scientific Computing Environments") and other areas of concern to the PAC. To assist continued communication, we believe it is useful to summarize our understanding from the meeting. This also enables PAC and TRG colleagues not in attendance to be informed.

First of all, we were delighted by your statement which you wrote on your board, "I believe the NSF Centers should exist with the largest peak power forever!" We view this to be a very important statement because of our (PAC) concern about the future of the supercomputer centers.

As I stated at the meeting, the PAC's primary interest is to provide advice to aid the DASC in fostering this development. An essential ingredient for success is that the Centers be funded at a level that will enable them to fulfill their mission which currently is a matter of debate. As Paul Rotar described in his memorandum to you (via John Connolly) of December 15, 1986, "... staffing levels at three of the Centers (Princeton, Cornell, & Pittsburgh) are below that needed to provide a reasonable range of services." In that memo Rotar also discussed the issue of machine upgrades and the need to maintain the supercomputer centers at the state-of-the-art. We cannot put it better than his statement, "... the point of the above [discussion] is to illustrate that the Centers are very new and not at all mature. Funding is below adequate levels and the Centers feel that NSF has reneged on the cooperative agreements."

In light of the above, I reiterate our concern expressed at the meeting about the introduction of market mechanisms. The possibility of market mechanisms in your long-range plan, as suggested by Frederick P. Brooks, Jr., in his letter to you of November 17, 1986, would have dire consequences for the Centers. We believe that this can only lead eventually to the dissolution of the Centers. If funds originally earmarked for the Centers are returned to the directorates, with the possibility of their use for alternative purposes, there is little basis, if any, to expect that they will end up back at the Centers.

Your separation of the networking effort from the DASC was also a matter of great concern. We are pleased, however, by Steve Wolff's statement that the networking effort will be directed towards facilitating supercomputer access as a highest priority. We recognize Wolff's consideration of other large data transfer needs of the computational science community in addition to supercomputer output. We understand that the composition of the PAC will be augmented to include persons to advise primarily on networking.

We discussed the importance of interdisciplinary computing groups. We will work with you and DASC to develop mechanisms to facilitate their creation. We recognize that this is not an easy matter to address. The directions of these projects should be dictated by the disciplines, but it is important for their success that computer scientists not be placed in a subsidiary role.

We see the need for various disciplines to develop projections of future needs in supercomputing. These projections should include not just needed cycles but also peripherals, software, communications, as well as management and priority setting mechanisms. Here we have as a model the efforts developed over the years at NCAR. It is timely to develop the steps to have such studies carried out which should involve respected scientists in the discipline in the broad sense, not just those involved with computational science. In this connection it would be important to involve the various NSF disciplinary divisions.

The present situation for the Centers is an uncomfortable one in many respects because of the limited funding base, but further because there are new demands being placed on them without additional funds.

When we have seen budget projections not being met and funds redirected from the supercomputer facilities, the effect is to raise grave concerns of many members of the PAC. The potential of diverting Centers from their intended role of supporting research in science and engineering towards a role that is more directly computer science at a time when staffs are limited can have a devastating impact on the quality of services in all of the Centers. Without new funding such changes must be discussed fully with the PAC and the broader community to arrive at a concensus for action.

The PAC is eager and willing to meet with you to discuss further the above and other issues related to the supercomputer initiative. We believe that timely meetings on these issues are essential and in instances cannot be held for the biannual PAC meetings.

I trust the above coincides with your recollection of our meeting. If there are concerns, please contact me. We look forward to continuing discussions.

Sincerely yours,

Bill

William A. Lester, Jr.
Professor of Chemistry
Chair, NSF PAC of DASC

mn

cc: Dr. E. Bloch
Dr. J. Connolly
NSF/DASC Program Advisory Committee
NSF/DASC Technical Review Group

Biographical Sketch of William Alexander Lester, Jr.

William A. Lester, Jr., is Professor of Chemistry at the University of California, Berkeley, and a Faculty Senior Scientist in the Materials and Chemical Sciences Division of Lawrence Berkeley Laboratory.

A native of Chicago, Lester received his early education in the Chicago public schools. In 1958 he graduated from the University of Chicago with a bachelor of science degree in chemistry and the following year earned a master of science degree in the same field. He then studied at The Catholic University of America, earning a doctor of philosophy degree in chemistry in 1964.

Lester's professional experience began as a theoretical physical chemist for the National Bureau of Standards while pursuing graduate studies at Catholic University. From 1964 through 1968 he was associated with the University of Wisconsin, Madison, engaged in research in molecular collision theory and electronic structure of molecules, and in teaching undergraduate physical chemistry and graduate courses in theoretical chemistry, while serving as Assistant Director of the Theoretical Chemistry Institute.

In 1968 he joined the professional staff of IBM Research Laboratory in San Jose, California, and conducted research in quantum chemistry and molecular collisions. In 1975 Lester moved to the IBM T. J. Watson Research Center in Yorktown Heights, New York, where he was a member of the Technical Planning Staff of the Director of Research with responsibility for science in all IBM Research Division laboratories (Yorktown, San Jose, and Zurich). From 1976 to 1978 he was manager of the molecular interactions group at the IBM San Jose Laboratory.

Lester, in 1978, was chosen as director of the National Resource for Computation in Chemistry (NRCC), located at the University of California's Lawrence Berkeley Laboratory. In that position he organized and directed the nation's first unified effort in chemistry, concentrating on improving computational efforts of chemists by making available information on new computational methods, developing computational algorithms and related software, as well as conducting research in chemistry that utilized computational methods. He also held the positions of Associate Director and Staff Senior Scientist at LBL.

At present, Lester is the chairman of the Program Advisory Committee (PAC) of the NSF Division of Advanced Scientific Computing. In 1986 he served as chairman of the subcommittee of the PAC for the supercomputer centers.

He is a member of the American Chemical Society (Chairman, Division of Physical Chemistry, 1979; Treasurer, Division of Computers in Chemistry, 1974-77; Secretary-Treasurer, Wisconsin Section 1967-68); Fellow of the American Physical Society (Chairman, Division of Chemical Physics, 1986-87), member of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE) (National Executive Board, 1984-87), Sigma Xi, and the American Association for the Advancement of Science.

Honors he has received include the 1983 Alumni Achievement Award in Science of The Catholic University of America Alumni Association, the Percy L.

Julian Award in Pure or Applied Research (1979), and the Outstanding Teacher Award (1986) of NOBCChE.

He has also served in a number of professional capacities: National Academy of Sciences/National Research Council Committee to Survey the Chemical Sciences, 1982-84; American Chemical Society Task Force on Large-Scale Computing, 1983-84; Panel for Chemical Physics, National Bureau of Standards, 1980-83; Specialist Editor, Computer Physics Communications, 1981-86; editorial boards of the Journal of Computational Chemistry 1979- ; International Journal of Quantum Chemistry, 1979- ; Journal of Physical Chemistry (1979-81); Chemistry Division Advisory Panel, NSF 1980-83; United States National Committee, International Union of Pure and Applied Chemistry, 1976-79; Chairman, Gordon Conference on Atomic and Molecular Interactions, 1978.

Lester resides in Oakland, California.

Dr. **Sugar**. Mr. Chairman, I'd like to thank you for the opportunity to appear here today, and present my views on the supercomputer centers.

Mr. **Walker**. Let me ask whether folks can hear in the back. Is it strained at all? Really pull those mikes in. I think you have to be within about 2 inches for it to really pick it up directly and that would help.

Dr. **Sugar**. Is that better?

Mr. **Walker**. That's better when you push like that.

Dr. **Sugar**. Okay.

My perspective is that of a university scientist who is using the supercomputer centers. In my opinion, the establishment of the National Science Foundation Supercomputer Centers has already had a major impact on research at American universities, and I believe this impact is certain to grow during the coming years.

Many of the important research problems in science and engineering are of such complexity that they can only be studied with the aid of the most powerful existing computers. These problems include such basic issues as the properties of the fundamental building blocks of matter, and the formation of stars and galaxies. They also include such practical problems as the structure of materials and the prediction of the weather. To work on the leading edge of such problems, one must have access to significant supercomputer time. Supercomputers are qualitatively different from the workstations and the minicomputers commonly available on university campuses. They are truly a unique research tool.

Until very recently, adequate access to supercomputer time was simply not available to most university scientists. If I may cite a personal example, two years ago several colleagues and I were working on a large scale calculation of the properties of quarks and gluons, the fundamental building blocks of nuclear matter. Part of our work was carried out on a Control Data Corporation Cyber 205 supercomputer. It was simply not possible for us to obtain even a fraction of the supercomputer time we needed for this study in the United States. Virtually all of the Cyber 205 phase of the project was carried out on a machine at the University of Karlsruhe, which was available to us because we had the good fortune to have a German collaborator. Thus a group of primarily American based scientists was forced to go abroad to use an American made supercomputer. This was not an uncommon occurrence, although of course, not all American scientists are so fortunate as to have well placed foreign collaborators.

The establishment of the NSF centers has dramatically changed the computing landscape. They are providing experienced supercomputer users with the computing powers that they have long needed, and they are opening up new lines of research for those who have not previously used supercomputers. If my field is indicative, and I'm sure that it is, the centers are already producing outstanding research in a wide variety of areas.

The supercomputer centers are also having an important effect on the training of the next generation of scientists and engineers. Before their establishment, one could already see the difference between the approach of older scientists such as myself, who were trained before the beginning of the computer revolution, and younger scientists, who were trained after the time that access to minicomputers became readily available.

It is clear to me from watching the students in our group begin to use supercomputers during the last year, that there'll be an equally large difference between them and their predecessors. It is not simply that we are training a group of young people who will go into industry and academia knowing how to use the latest hardware and software. We are significantly broadening the way that they think about scientific problems, and we are expanding the range of problems that they are prepared to undertake. I believe that this is a very significant development.

I also believe that the centers will have an important effect on the computer industry itself. By the very nature of their work, university researchers tend to push computer hardware and software to their limits. In developing new approaches to problems, and new software tools, the university scientist will undoubtedly have an important effect upon the industry. Although it is not yet as visible as the effects on research and training, I believe that in the long run, it will be equally significant.

In my invitation to testify before you, particular interest was expressed in my experience in using the centers. I've only used the San Diego supercomputer center myself, however in preparing my testimony, I've talked to colleagues who have used other centers. In my very small and unscientific sample, there was general agreement that the managers of the centers have done a superb job in bringing the machine into stable operation. They are already being heavily and productively used.

Extensive mathematical and graphics packages are available on the machines, but there is certainly room for further software development, and for improvement in documentation. The staffs of the centers appear to be knowledgeable, and are extremely helpful.

The centers presently have, or are in the process of obtaining state of the art hardware. In order to protect the investment that has been made in them, it will be important to continually upgrade the hardware to keep it on the leading edge of technology. I think this is of crucial importance. It will also be important to keep the capacity of the centers in the balance with the load being placed upon them. For example, I have the impression that the San Diego center is already approaching saturation.

Now that the supercomputers themselves are operating successfully, the highest priority should be to create a network which will provide remote users with satisfactory access to them. This should include the ability to use the supercomputers interactively, to transfer the large data files they produce back to the user's home institutions for analysis, and the ability to transmit high resolution graphics displays. Without adequate service to remote users, the centers will not become the national facilities they are intended to be.

It would appear that the officials of the National Science Foundation and of the centers appreciate the importance of networking, and indeed significant progress has been made during the past year, both in creating a backbone network, and in connecting many institutions to the centers.

However, I know from the experience of my own campus, that there is still much work to be done before an adequate network is in place. In addition, in the long run, the backbone network and the communications with major research centers, will undoubtedly have to be upgraded from the present 56kb to T1 service. It will clearly be expensive to maintain such a network; however without it, much of the potential of the centers will be lost.

I believe that this is an area for joint action by the universities and the NSF. Universities certainly have the responsibility for providing campus networks which link individual computers and workstations to gateways, but it seems to me that it is only the National Science Foundation that can assume the responsibility for linking the campuses to the networks.

An area in which the centers could play a particularly useful role is software development. I would include software for communication between supercomputers and workstations, development of specialized software packages, and graphics. At present, supercomputers are significantly more difficult to use than the minicomputers which most university users are familiar with.

If the centers are to be successful in bringing the power of supercomputers to a significantly wider community, then this problem needs to be addressed. It has quite rightly been given a lower priority than bringing the machines on line, and networking. However, from my conversations with officials of several of the centers, I believe that there is a real appreciation of the importance of further software development. It is an area in which the centers could serve not only their immediate users, but the wider scientific community, and the computer industry as well.

Mr. Chairman, I'd like to make one final point, which I believe is very important. I believe that the supercomputer centers should be part of a balanced program which provides state of the art computing facilities to research workers at American universities. Such a program is essential in order to maintain our leadership in science and technology. The supercomputer centers are a crucial part of such a program. They provide unique tools which are essential for the study of many problems.

However, a balanced program should also include the acquisition of a wide range of facilities, including workstations, minicomputers, array processors, mini-supercomputers, etc. Workstations are needed for communication with supercomputers, for analysis of the data they produce, and for high resolution graphics.

In addition, many of the smaller and medium range problems facing scientists and engineers can be solved more readily and at lower cost on workstations and minicomputers than on supercomputers. Using supercomputers to solve such problems is wasteful and decreases their availability for the large scale problems for which they are uniquely suited.

Array processors, hypercubes, and mini-supercomputers have recently come on the market, which for some problems provide a significant fraction of the power of a supercomputer at a small fraction of their cost. Such machines can in no way replace supercomputer centers, but from my own experience in using one such array processor, the Star Technology ST-100, I am convinced that such specialized machines can be extremely useful research tools.

Indeed, one of the unique features of the Cornell center is the study of innovative users of such array processors. Making such machines more readily available to university scientists would not only further research, it would help to stimulate a part of the computer industry that is currently producing innovative ideas.

To summarize then, the creation of the National Science Foundation supercomputer centers, and the start in the construction of a national computer network, have been major achievements. In the coming years, it will be essential to complete the network, and to maintain the centers at the leading edge of technology. It will also be important to broaden the national effort to provide university scientists and engineers with a complete range of computing facilities.

Thank you very much.

Mr. **WALKER**. Thank you very much. We will turn then to Mr. Roberts.

[The prepared statement of Dr. Robert L. Sugar follows:]

THE NATIONAL SCIENCE FOUNDATION SUPERCOMPUTER CENTERS

Robert L. Sugar
Department of Physics
University of California
Santa Barbara CA 93106

The establishment of the National Science Foundation Supercomputer Centers has had a major impact on research at American universities, and this impact is certain to grow during the coming years.

Many of the important research problems in science and engineering are of such complexity that they can only be studied with the aid of the most powerful existing computers. These problems include such basic issues as the properties of the fundamental building blocks of matter and the formation of stars and galaxies. They also include such practical subjects as the structure of materials and the prediction of the weather. To work on the leading edge of such problems one must have access to significant amounts of supercomputer time. Supercomputers are qualitatively different from the workstations and minicomputers commonly available on university campuses, and they open unique research opportunities.

Until very recently adequate supercomputer time was simply not available to most research workers at American universities. If I may cite a personal example, two years ago several colleagues and I were involved in a large scale calculation of the properties of quarks and gluons, the fundamental constituents of nuclear matter. Part of our work was carried out an a Control Data Corporation Cyber 205 supercomputer. It was not possible for us to obtain even a fraction of the supercomputer time we needed for this study in the United States. Virtually all of the Cyber 205 phase of the project was carried out on a machine at the University of Karlsruhe which was available to us because we had the good fortune to have a German collaborator. Thus a group primarily made up of American based scientists was forced to go abroad to use an American made supercomputer. This was not an uncommon occurrence although, of course, not all American scientists were so fortunate as to have well placed foreign collaborators. The establishment of the NSF centers has dramatically changed the computing landscape. They are providing experienced supercomputer users with the computing power that they have long needed, and they are opening up new lines of research to those who have not previously used supercomputers. If my own field is indicative, as I am certain it is, the centers are already producing outstanding research in a wide variety of areas.

The supercomputer centers are also having an important effect on the training of the next generation of scientists and engineers. Before their establishment one could already see the difference in approach between older scientiests such as myself, who were trained before the beginning of the computer revolution, and younger scientists who were trained after the time that minimcoputers had become readily available. It is clear to me from watching the graduate students in our group begin to use supercomputers during the last year that there will be an equally significant difference between them and their predecessors. It is not simply that we are training a group of young people who will go into academia and industry knowing how to use the latest hardware and software. We are significantly broadening the way they think about scientific problems, and we are expanding the range of problems that they will be prepared to undertake.

I believe that the centers will also have an important effect on the computer industry itself. By the very nature of their work university researchers tend to push computer hardware and software to their limits. In developing new approaches to problems and new software tools the university scientists will undoubtedly have an important impact on the industry. Although it is not yet as visible as the effects on research and training, I believe that in the long run it may be equally significant.

In my invitation to testify before you particular interest was expressed in my experience in using the centers. I have only used the San Diego Center, but in preparing my testimony I have talked to colleagues who have used other centers. In my very small sample there was general agreement that the managers of the centers have done a superb job in bringing the machines into stable operation. They are already being heavily and productively used. Extensive mathematical and graphics packages are available on the machines, but there is certainly room for further software development and for improvement in documentation. The staffs of the centers appear to be knowledgable and are extremely helpful. The centers presently have or are in the process of obtaining state of the art hardware. In order to protect the investment that has been made in them it will be important to continually upgrade their equipment to keep it on the leading edge of technology. It will also be important to keep the capacity of the centers in balance with the load being placed on them. For example, the San Diego Center already appears to be approaching saturation.

Now that the supercomputers are operating successfully, the highest priority task facing the National Science Foundation and the management of the centers is to create a network which will provide remote users with satisfactory access to them. This should include the ability to use the supercomputers interactively, to transfer the large data files they produce back to the users' home institutions for analysis, and the ability to transmit high resolution graphics displays. Without adequate sevice to remote users the centers will not become the national facilities they are intended to be. It would appear that officials of the National Science Foundation and of the centers appreciate the importance of networking, and significant progress has been made during the past year both in creating a backbone network and in connecting many institutions to the centers. However, I know from the experience of my own campus that there is still much work to be done before an adequate network is in place. In the long run the backbone network and the communication links with major research centers will undoutedly have to be upgraded from the present 56kb to T1 service. It will clearly be expensive to maintain such a network; however, without it much of the potential of the centers will be lost. I believe that this is an area for joint action by the universities and the NSF. The universities should certainly have the reponsibility for providing campus networks which link individual computers or workstations to gateways. It seems to me that the National Science Foundation has the responsibility for linking the campuses to the centers.

An area in which the centers could play a particularly useful role is software development. I would include improvements in operating systems, communication between supercomputers and work stations, development of specialized software packages and graphics. At present supercomputers are significantly more difficult to use than minicomputers. If the centers are to be successful in bringing the power of supercomputers to a significanlty wider community, then this problem needs to be addressed. It has quite rightly been given a lower priority than bringing the machines on line and networking. However, from my conversations with officials of several of the centers, I believe that there is a real appreciation of the importance of further software development. It is an area in which the centers could serve not only their immediate users, but the wider scientific community and the computer industry as well.

I believe that the supercomputer centers should be part of a balanced program to provide state of the art computing facilities to research workers at American universities. Such a program is essential in order tq maintain our leaderhip position in science and technology. The supercomputer centers are a crucial part of such a program. They provide unique tools which are essential for the study of many problems. However, a balanced program should also include the acquisition of a wide range of facilities including workstations, minicomputers, array processors and mini-supercomputers. Workstations are needed for communication with supecomputers, for analysis of the data they produce and for high resolution graphics. In addition many of the smaller problems facing scientists and engineers can be solved more readily and at lower cost on workstations and minicomputers than on supercomputers. Using supercomputers to solve such problems is wasteful and decreases their availability for the large scale problems for which they are uniquely suited.

Array processor, hypercubes and mini-supercomputers have recently come onto the market which for some problems provide a significant fraction of the power of a supercomputer at a small fraction of their purchase and operating cost. Such machines can in no way replace the supercomputer centers, but from my own experience in using a Star Technologies ST-100 array processor, I am convinced that they can be extremely useful research tools. It should be noted that one of the unique features of the Cornell Center is the study of innovative uses of array processors. Making such machines more readily available to university scientists would not only further research, it would help to stimulate a part of the computer industry that is currently producing very interesting new ideas.

The creation of the National Science Foundation supercomputer centers and the start in the construction of a national computer network have been major achievements. In the coming years it will be essential to complete the network and to maintain the centers at the leading edge of technology. It will also be important to broaden the national effort to provide university scientists and engineers with a complete range of computing facilities.

Biographical Sketch

Robert L. Sugar

I received an A.B. degree in physics from Harvard in 1960 and a Ph.D. in physics from Princeton in 1964. I am presently a professor of physics at the University of California, Santa Barbara. My research interests are in the fields of high energy and condensed matter physics. In high energy physics I am studying the properties of quarks and gluons, the fundamental building blocks of nuclear matter. In condensed matter physics my work centers on the electronic structure of materials. My research in both of these areas involves large scale numerical simulations for which I have used Cray-XMP and Cyber 205 supercomputers and Star Technology ST-100 array processors.

I was one of the co-founders of the National Science Foundation's Institute for Theoretical Physics, and I served as its deputy director for four years. I have been involved in planning our campus's communication links with the supercomputer centers, and I have served as the campus representative on the San Diego Supercomputer Center Consortium Steering Committee for the last six months.

Mr. ROBERTS. Mr. Chairman, members of the Subcommittee, I have submitted a written statement and at this time I would like to just summarize the principal points for you.

Computer networking until recently has been an obscure branch of science. It has come into a great deal of visibility recently because of advances in the development of microcomputer technology and also because of advances in supercomputer technology. We have the situation in which we have very powerful small machines and we have very powerful large machines which need to be linked together. We have not, on a national basis, made sufficient investment in networking technology to allow that to happen in the manner in which we would all like it to happen.

There is, if you will, a missing middle in our equation about the advancement of science where networking is involved. This is not a single issue problem; it involves improved technology, wider access, better management and an appropriate allocation of funds.

It is not a single agency or institution problem. We believe, the constituency I represent, which is over 400 universities and colleges in the United States, that the National Science Foundation is best equipped to provide federal leadership in working out the difficulties in which we presently find ourselves.

In summary, I would like to say that our recommendation is that the Congress and the Administration take a broader view of computer networking as a national priority for higher education than is represented in the Foundation's present submission.

The present budget document you have before you asks for approximately $4 million to move from a level of $9 million to $13 million. Those funds are vitally needed, and I urge you to promote and approve that funding.

I also would like to urge you to take a broader view of the situation and recognize that these tools are needed outside the somewhat narrow domain of supercomputer access with which they have been historically associated in the Foundation's budget.

Thank you.

[The prepared statement of Mr. Roberts follows:]

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The Need for A National Higher Education Computer Network

Statement by Michael M. Roberts, President, EDUCOM,
to the Science, Research and Technology Subcommittee
United States House of Representatives
February 25, 1987

Introduction

EDUCOM is a non-profit consortium of 463 institutions of higher education in the United States, representing a graduate and undergraduate enrollment of more than two million students. EDUCOM was organized in 1964 for the purpose of promoting and assisting the use of computer and communications technology in higher education. Our programs, conferences, seminars, and publications have played a leading role in the sharing and dissemination of information technology and techniques among colleges and universities for many years. We provide technical and management services for BITNET, the largest general purpose computer network in higher education, which currently connects over twelve hundred computers on two hundred and fifty campuses. In addition to the sharing possible over BITNET within the United States, it also reaches twenty-five foreign countries by connection to academic networks in Canada, Mexico, and abroad.

Goals for a National Network

My purpose today, in conjunction with the subcommittee's review of the FY88 authorization bill for the National Science Foundation, is to draw your attention to the urgent need for increased federal sponsorship and support for a national higher education computer network. The goals of this network can be summarized as follows:

- To advance the quality and productivity of academic research and instruction by expanding the opportunities for collaboration and sharing of scholarly work through more effective communication.

This statement was endorsed by the Higher Education and Technology Committee of the National Association of State Universities and Land Grant Colleges on February 20, 1987.

- To shorten the time required for transmission of basic research results from our campuses to the private sector and to federal agencies, thus enhancing our national research and product development capability, and potentially, the standard of living of all our citizens.

- To improve our educational system by widening computer network access by faculty and students to expensive, specialized information resources such as research library holdings, discipline specific databases, and the vast public domain information repositories of federal and state governments.

- To broaden the geographical distribution of research activity by allowing wider collaboration throughout the academic community.

- To serve as an operational testbed on which advanced technical concepts in computer networking can be developed and tested by university research and professional staff.

Achieving these goals for a national educational network will not be easy. Although a pioneering partnership of federal agencies and university researchers in the 1970's gave the United States a leading position in network technology, that lead has been seriously eroded in recent years by failure to invest in continuing technical improvements. In addition, important issues of access, management, and funding must be addressed if the benefits of a national network are to be realized in our colleges and universities.

National Network Issues

Improved Technology. It is now widely projected that further advances in the use of computer technology in many disciplines will require network transmission speeds of hundreds of millions of bits per second, yet the vast majority of faculty and students working with computers, if they have any network access at all, are limited to ten thousand bits per second or less. Substantial increases in speed are required to allow the effective transmission of pictorial and graphical information critical to the needs of today's computational based science.

Access. At the present time, access to computer networks is restricted by a variety of administrative and funding policies of sponsoring agencies and individual institutions. The result is that in many cases faculty and students are denied the use of an important tool in their academic work. Present policy must be changed so that wider access is established as an immediate goal of the network.

Management and Governance. In addition to the need for increased support for networking research and development, there is an urgent requirement to provide an effective focus for the networking programs which support higher education now fragmented among a dozen or more federal agencies. As part of a new management structure for a higher education computer network, an effective partnership can and must be forged among government, industry and education to bring the potential benefits of open and widely available educational access to computer based information resources into reality.

Funding. No accurate estimate is available on funds already being expended on computer networking in higher education through the variety of disciplines and supporting agencies but it is in the tens of millions of dollars per year. Improvements in technology and increased network access will require additional funds, some of which can be obtained by more efficient use of amounts already available, especially at the federal level.

Recomendations for Federal Action.

EDUCOM strongly supports recent steps by Director Bloch to create a national research network as a high priority program within NSF. This network is not only an essential step in the overall federal program for strengthening American scientific and economic competitiveness, but it also will provide a technical foundation for a national higher education computer network.

We suggest for your consideration the following immediate steps:

1) Ask that NSF and the National Science Board expand current scientific network studies to include a comprehensive review of the broader issues (needs, programmatic, management and fiscal) attendent to the development of a national higher education computer network.

2) Widen the scope of federal support of computer networking to include the full range of instruction and research activities in higher education.

National Association
of State Universities
and Land-Grant Colleges

Robert L. Clodius President

RESOLUTION

The Higher Education and Technology Committee of the National Association of State Universities and Land-Grant Colleges strongly supports a national commitment to the planning and implementation of a comprehensive computer network for higher education.

The networking efforts of the higher education, government, and business communities to date have provided a valuable start. We now have before us an important opportunity to capitalize on the technological and educational base we have established and to make important advances which should not be missed. Without a comprehensive effort, however, the United States may lose what lead it has internationally. A network or hierarchy of networks emerging from modification, interconnection and/or integration of existing networks to serve national research and education needs will be critical to maintaining the nation's scientific leadership and economic competitiveness.

The Committee has reviewed and endorses the testimony on networking issues of Michael Roberts, President of Educom, prepared for the House of Representatives Subcommittee on Science, Research and Technology hearing of February 25, 1987.

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Michael M. Roberts
42 Linden Lane
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Mr. Roberts is serving as President of EDUCOM, a Princeton based consortium of colleges and universities devoted to cooperative programs in information technology, while on leave from Stanford University. He also directs the EDUCOM Networking and Telecommunications Task Force, formed by a group of 28 universities to coordinate programs and policies affecting computer networks on campuses.

At Stanford, he is Deputy Director, Information Technology Services, with responsibility for management and technical direction of the university's central computing facility, telecommunications system, and management information systems.

For the past fifteen years, he has been engaged in technology management for Stanford, including major projects in telecommunications, computing facility design, information systems design, and financial management of computing systems.

He has been a consultant on the design and application of information systems to a number of universities and higher education organizations, including the Chairmanship of the Task Force on Cost Finding Principles of the National Center for Higher Education Management Systems. He holds a reserve Captaincy in the United States Navy and has headed more than a dozen studies of information systems and data processing commands for the Navy.

Mr. Roberts is a director of a number of firms involved in computing and information technology including Disabled Programmers, Inc., and Tioga Publishing, Inc.

He holds an undergraduate degree in Psychology and a graduate degree in Business from Stanford.

Mr. Roberts is married and has two grown children.

Mr. WALGREN. Thank you very much, Mr. Roberts, we appreciate that statement. Well, let me start some discussion with the panel at this point. What I hear you saying is that there are insufficient funds in the present projections and in fact, someone indicated that funds were actually being redirected from the supercomputer centers, and that was mentioned in your letter. There was actually some redirection of funds.

And I get this conflict between the emphasis on networking versus something else that I don't really understand what it is. Can you tell me a little bit more about where is the competition for the available dollars that are being put forward? It is apparently or perhaps the fear is not going to networking when it should—is that the testimony?

Dr. LESTER. The aspect contained in the letter to Gordon Bell revolved primarily around the separation initially of the original Office of Advanced Scientific Computing into two divisions. And part of the concern there was related to whether or not the supercomputing initiative per se would retain highest priority when indeed there are other dimensions for which networking is important.

Mr. Roberts has alluded to the broader aspects of that in his remarks. And I think to some extent that is the dimension which some of us on the Program Advisory Committee are concerned about.

So it's a matter, from my perspective, of growth; that we should, at the same time that we're bringing the supercomputing facilities to maturity, develop networking; that other dimensions which are also important in terms of our national focus for networking possibly take a secondary role until the supercomputer centers themselves are functioning fully. So that's the aspect of competition that I alluded to in my letter to Bell.

Mr. WALGREN. When we talk about functioning fully, are we at anywhere near capacity in these centers?

Dr. LESTER. Some of the centers are effectively saturated, as indicated a few moments ago by Dr. Sugar. But the networking aspect is not there fully in terms of users from various other locations utilizing various supercomputer facilities. So there's the aspect of maturation of network capability that's important, as well as the upgrade of current hardware and software in the supercomputer centers at present, and that these need to go hand in hand.

And so there is this competition in terms of all of these important domains that have to be addressed, and at the current funding levels there are some problems in achieving this maturation.

Mr. WALGREN. Current funding levels being what? What are the current funding levels?

Dr. LESTER. I can't give you the actual numbers.

Mr. WALGREN. Something like $47 million in this year's budget. What are the projections for this function in the President's budget?

Dr. LESTER. I don't have those numbers in front of me. Possibly someone else might.

Mr. WALGREN. Can you give us some indication of the degree of the shortfall? Now admittedly, as I understand it, we've sort of frontloaded this process. We were trying to bootstrap ourselves into these centers because the Administration was not providing even a modicum of funding. As I understand it, the original needs assessment were ranging in the $200 million range and the Administration suggested $20 million; something in terms of one-tenth of the need. We then bootstrapped it up to something like $40 million plus.

But in establishing these centers, I don't know that we knew where we were going to get the money for the next several years. Is that where we are? Is that the crunch?

Dr. LESTER. That in part, but also because of aspects of problems and some difficulties associated with various centers. Some funds have not been made fully available, and for quite good reasons, as a matter of fact, in terms of say vendors not delivering products and so forth.

But notwithstanding that, still more funds should have been, from my perspective, made available because of the demands placed on center managements to try and put their facilities in a functioning mode to satisfy a broad user base because of the issue of the community not being reasonably satisfied in terms of the capability that might be made available. And so it's all of these pressures pushing onto centers to deliver in a constrained financial environment that has caused these difficulties.

Mr. WALGREN. Can anyone comment on what the increase in funding ought to be? And admittedly, this has to be sort of a judgment thing; we can't all have everything we want, and yet we started down the road to these facilities. I think all of us appreciate that science has a unique role and therefore should compete, and particularly supercomputing science—I think we all appreciate the uniqueness of its contribution—and should therefore be able to do more in this area than we may be able to do in others. A reasonable person would.

Can you suggest levels of support that you would like to see, and let me ask all of the panelists that general question?

Dr. LESTER. Well, as I indicated in my testimony, I think at a minimum, the funds that were initially indicated and agreed upon in the cooperative agreements, that that level be met. I don't have the dollar figures in front of me as to what is constituted there.

But as indicated in my letter to Gordon Bell, there is a sense I think from some of the centers that indeed, the Foundation has not lived up to its agreement in terms of financial support. But there are good reasons why the Foundation did what it did. Now insofar as the number of years that have passed, the two years that the centers have been in operation, it appears we are approaching the point where indeed those monies originally agreed upon should be made available so that the catch-up, which I think can be more easily done now that the centers have been established to a certain extent, that catch-up can occur very shortly. So those funds need to be made available to them.

Mr. WALGREN. Dr. Sugar.

Dr. SUGAR. I'm afraid that it's—I'm not in a position to give you a direct answer as to dollar figures because I'm simply not an expert on cost of supercomputers or of networking. But the one thing that I would like to reiterate from my prepared statement has to do with the question of networking and access. I believe the figures are about 90 percent of the users of the supercomputers are not located at the center sites. And again, these ought to be national facilities. They can only be national facilities with national user groups if there is good access, and that means good networking. And that means networking with good links to all of the major research universities. Otherwise, this isn't a national program and it's going to be very hard to justify maintaining it.

So I just can't stress too much the importance of really completing this networking process. And I do believe that it's understood at the NSF—I don't know whether it's being adequately funded; I suspect that it isn't.

Mr. **Walgren**. Any other comments? Mr. Roberts.

Mr. **Roberts**. I'm not really here to discuss the networking issues. I'm sure that you would get some very provocative testimony from the center directors should you choose to ask them.

Mr. **Walgren**. Mr. Boehlert?

Mr. **Boehlert**. Do you feel the computer directorate has a clear plan for the future of the centers? Dr. Lester, do you want to start with that one?

Dr. **Lester**. Yes, I do. I think that they have a vision in terms of what they would like to see happen. A lot of work went into the planning for the centers and I think the subsequent experience of course leads to some modification of plans one initially has.

But we have seen a change from the initial notions as to the total number of centers being of the order of three or four times the number that we're talking about now. And so as a consequence, I think there is the increasing notion of expanding the dimension and capability of each of the existing centers, for example.

The vision of what's possible is still a growing one, but I think the general blueprint is available.

Mr. **Boehlert**. How about you, Dr. Sugar? Is there a clear plan, do you think?

Dr. **Sugar**. Well, I have talked to the leaders of several of the centers, and I believe that they do have clear plans about where they would like to go. And they seem very sensible to me.

They have doubts as to whether they will receive the funding to do everything that they would like to do, but I certainly think that they have vision and plans, yes.

Mr. **Boehlert**. Well, the centers. How about the directorate; do you think they're on the same wave length?

Dr. **Sugar**. I just can't answer having—I'm just not familiar enough with the thinking of the directorate itself. I'm sorry, sir.

Mr. **Boehlert**. Let me ask another question. Should the supercomputer centers be viewed differently now that they're up and running and we've got other universities coming into it, buying their own equipment? What should be the direction in which we proceed? Should we stick to the original program and continue to put more money into the original centers? Should we broaden the base or should we say to the centers—and this is a tall order—all right, you're already up and running; now we've got to put our attention elsewhere.

Dr. **Lester**. I would like to respond to that.

Mr. **Boehlert**. I think I know what your answer will be.

Dr. LESTER. Yes, I think, as I indicated in my testimony, that the centers are not mature as yet, that indeed they need to be maintained at the cutting edge of technology if they are to deliver the kinds of guidance, educational dimensions and access to state-of-the-art capabilities that we would plan for such a resource.

It was the case not so many years ago that a wide variety of universities attempted to have, at the time, state-of-the-art computing capabilities. And depending upon a variety of factors we saw them in some instances do well and in other instances not so. But I think now in our current, very competitive international environment it is essential that we have these centers maintained at the cutting edge. I think this is a very important aspect of a unique program which I think can provide us with a great deal if funded adequately.

Dr. SUGAR. I very strongly agree with Dr. Lester. I think that it is very important to have a few centers that are truly at the leading edge. And if one is to do that, I think you cannot spread yourself too thin. I think it's wonderful that some universities are taking it on their own initiative, I think in part inspired by the creation of the centers, to obtain their own supercomputer facilities.

But I think it's very important that the National Science Foundation concentrate on keeping a few centers really at the edge, and that means continually upgrading them as new machines come on the market and new things come on line. And if we try to spread ourselves thin and produce many, many centers, we simply won't be able to do that.

Mr. BOEHLERT. Mr. Roberts, you're nodding in agreement. Is that——

Mr. ROBERTS. Yes, sir, I certainly agree with that, and I think that the Committee needs to keep in mind here we're talking about an ongoing process of technology transfer. The machines that are developed by our best computer scientists and engineers today will be the machines that the community at large will use to solve problems tomorrow. Both are equally important.

Mr. BOEHLERT. I have here, if I may, a letter from Dr. Bell of last October, and there was attached a letter to all the center directors. But in this letter he's talking about the Advisory Committee having an issue of the highest priority, and if I may I'd like to quote exactly from the letter.

He says,

> With the exception of San Diego, the use seems to be quite local and limited. I believe the user base is not expanding as rapidly as is necessary to justify the half billion dollars that will be spent for this program.

Can I have a reaction from the three of you to that one? How about you, Dr. Lester?

Dr. LESTER. I think there's an aspect of experience in this regard in terms of the amount of time it takes to bring users on board facilities of this sort. And I would like to draw upon my own experience, having headed as director an experiment in supercomputing some years ago, an activity which did not have a supercomputer in that sense, the National Resource for Computation and Chemistry. It takes time for the user community to reach that point.

What we are doing is putting—we, the National Science Foundation—putting funds upfront to establish the capability. I think the tide is there, it's happening. It is induction time associated with these kinds of activities.

Mr. BOEHLERT. So it's not a cause for great alarm?

Dr. LESTER. I don't see it at this point. I think we have to, of course, keep careful tabs on this, and this is part of the role of the Program Advisory Committee, to assist in this process. But what we see now, 3000 users nationally, and if one just scans the data that the National Science Foundation has in this respect, we see people, outstanding scientists, who were not computationally directed previously, moving in that direction, developing new insights into problems and so forth.

Mr. BOEHLERT. Dr. Sugar.

Dr. SUGAR. Again, the information I have is based on a small amount of data, and you probably want to get more accurate data, but the impression I have is that possibly San Diego got started faster but that the use of the other centers has grown very considerably. And I certainly have the impression that all of the centers are now being very widely used, and that in all of the centers the use is not restricted to local people.

If that should happen on a long-term basis it would be a very, very bad thing. I don't believe that that's happening, and I don't believe that that is a long-term problem at all.

But again, to ensure that that doesn't happen, one will have to really maintain excellent networking facilities.

Mr. BOEHLERT. Now I've got—and I want everybody to pay close attention because I'm going to ask the same question of everyone today because I think it's extremely important. Talking about the mystery word and winning the $100, I've got another one for you that everyone in this town is talking about and it's called Superconducting Super Collider (SSC).

Now the President has requested somewhere in the magnitude of $4 to $6 billion for the project and I'd like to know what your views are of the project and what impact it might have on funding for research priorities, and if we have to make some choices, should we go with the SSC or should we say well, that's for another day and we've got to give more money to NSF. It's a tall order and one that we've got to come to grips with and I want the best advice I can get.

Dr. Lester, would you mind starting on that one?

Dr. LESTER. That is a very difficult question.

Mr. BOEHLERT. Yes, I know, but it is one we have to face and you are better qualified to address it than I am.

Dr. LESTER. Well, it's an important direction, of course, in terms of very high energy physics to have the capability of the superconducting super collider. I think even in that respect, it is essential that the kind of capability that can be made possible through supercomputing facilities not suffer in the environment in which one might develop such a machine.

I think the fact that supercomputing transcends all disciplines, it is utilizable by all of the sciences and engineering, that we stand to lose a great deal, I feel, if the program is shortchanged by having another project of this magnitude as proposed in terms of funding, have such an impact.

Dr. SUGAR. First, I should tell you that I am a high energy physicist and therefore very directly affected by this issue so you should know my prejudice.

I believe that the superconducting super collider is an extremely important initiative. I believe that it is necessary if we are to keep our leadership position in the field of high energy physics, if we are to continue to be able to train young people in this field. I hope very much that project will be funded. It is a tremendously exciting project. It is tremendously important.

However, the question you raise is a very important one. Even though I am a high energy physicist, I must tell you that I do not think we should fund the SSC if that means that we will destroy funding for the rest of science. We have a broad science program. The basis of that program, in my opinion, is the funds for the grants to individual scientists. I think that is the basis of our scientific success. These grants have been squeezed particularly in the last two years, so that it is very difficult for principal investigators, such as myself, to carry out the research that we propose.

I think that we ought to build the SSC, but that we ought to be very careful in doing so, that we do not squeeze the individual research grants to a point where we really hurt not just high energy physics but the whole range of science. I would say that is also true for the supercomputer centers. They are extremely important initiatives.

But, we cannot fund them at the expense of the individual research grants. That would be a terrible mistake. That would hurt all of science in the United States.

Mr. BOEHLERT. Mr. Roberts.

Mr. ROBERTS. I am neither a physicist nor a scientist directly.

Mr. BOEHLERT. Then you are an expert witness. [Laughter.]

Mr. ROBERTS. I have been associated at Stanford, for many years, with computing and with our linear accelerator and the staff of that facility. I think we all wish as citizens of the country that there was a way to do large scale science less expensively. We flinch when someone says $6 billion for a scientific project. On the other hand, we seem to have arrived at a point in the progress of scientific research in our society and on our planet where exploring fundamental limits is a very expensive proposition.

I would just echo the other testimony here this morning, that we have to look at it in the national context. We have to look at it in terms of our entire range of national resources to be deployed against all of our problems.

Mr. BOEHLERT. It is very important for us to hear from the scientific community, particularly someone like you, Dr. Sugar, that has a prejudice to start out with. In the ideal world, sure, let's go ahead, we will go with the $4 to $6 billion for the SSC and let's fund fully the supercomputer centers and let's do all these things. We'd love that.

As a practical matter, we have some very difficult choices to make. I'm trying to establish in my own mind and in my own thinking, where we should place the SSC request on a priority list in line with all the other requests that we have.

Of course, I probably should qualify that in saying that if the Energy Department says they are going to select a site in New York, it is number one. If it is anyplace else, it is far down the list. [Laughter.]

Mr. **Walgren**. Thank you, Mr. Boehlert. Mr. Hayes.

Mr. **Hayes**. First of all, I want to thank you, Dr. Lester, for restoring my faith in Cal Berkeley. My Legislative Director, Rob Caperno, has his degree from that institution and quite frankly, I was becoming very suspicious of its academic credentials.

I only want to ask two or three questions. They will help me, I think, in gaining an understanding and see if I am correctly perceiving the message you are trying to give to me.

If I were a local user, if I were a university administrator and if I were trying to put my work stations together for access; presently, what kind of cost am I looking at, who am I likely, from your present experience, to get it from, and how ought I be going about it? What would your suggestions for alternates to my present predicament be?

Dr. **Lester**. Well, with regard to building a local capability, that is the sense that I understand your question. One, of course, needs a local networking capability. The campus itself should be a network. A study, of course, should be pursued to that end by the campus committee concerned with that issue.

Furthermore, with the more recent interest and efforts on the part of computer vendors, there are those contacts that are possible in terms of establishing what the best basis of the building of that networking capability locally might be. There is, quite often, sharing and reduced educational discounts which facilitate that process. That again has to be one that is carefully thought out and pursued in terms of what is best for the campus, depending upon size and so forth.

With the advent of the supercomputer facilities, clearly one wants to have that as another tier of the capability for the local institution. So, in a certain sense, one often hears discussed three tiers of computing; the microcomputer, personal computer level followed by the super mini, so to speak, a capability that is locally resident, with the additional dimension of being able to hook into a supercomputer facility easily.

All of these dimensions require that one have a networking capability locally which then hooks into the national capability.

I don't know if that fully answers your question.

Mr. **Hayes**. What kind of cost—I know you are looking at $1 million for the super mini as an initial acquisition cost.

Dr. **Lester**. That's a large super mini; depending upon the size of the institution, because in many instances one finds—for example, at Berkeley, possibly representative of the very largest institutions, many such machines available. I have not looked at the actual dollar cost related to that dimension. That information is clearly available. For example, our Assistant Vice Counselor for Information Sciences and Technology at Berkeley wrestles with this on a day by day basis as Berkeley is being networked and these whole issues do come up.

I'm not as close to that problem as possibly I could be to answer your question fully.

Mr. **Hayes**. Really the only other question I have is as I understood all of you speaking of the goal of the centers themselves and the interlinking and being able to link up, how is that goal affected by the individual universities which have purchased the supercomputer facilities? How is our goal, as I understand it, being impacted by local users gravitating perhaps to some of the independently purchased supercomputers rather than under what was originally envisioned by the National Science Foundation?

Dr. **Sugar**. I think it is being aided by that because I think the problems that we are going to face in the NSF centers is not having enough cycles for all the people who want to use them, and to the extent that some universities provide their research workers with their own supercomputers, that will only aid the centers and help them from being saturated or at least delay that saturation.

I think it is a great help.

Mr. **Roberts**. I would just like to comment. There is a continuing debate in the scientific community and university community that has gone on for quite a number of years as to whether access to computing facilities should be program funded or should be based on some sort of fee structure.

My reaction to that as someone who has lived through some pretty hard blows on those kinds of issues is that it is important not to let the economic structure we choose get in the way of getting good science accomplished. This is not an either/or proposition. Those problems are solvable at both the agency level and the university level.

I should comment that the provision of funds in line item grant budgets for computing has been one of great controversy and is unresolved at this time.

Mr. **Hayes**. Thank you.

Dr. **Lester**. I would like to pursue this one step further. With regard to Berkeley, for example, which has its own supercomputer, but nevertheless, there are those of us who do use other supercomputing facilities, because of the capabilities that the national centers have. Although Berkeley is maturing in the sense of its own supercomputer capability, it does not provide the kind of access to other dimensions that a national facility can make available, so there are additional benefits.

Mr. **Walgren**. Thank you, Mr. Hayes. Mr. Buechner.

Mr. **Buechner**. Either Dr. Sugar or Dr. Lester, I would appreciate your response to this. I have been reading about the problems that our microchip industry is facing on the world market and especially in the area of the new super chips. Apparently, we have fallen dramatically behind on being the cutting edge of technology. There have been a lot of complaints about Japanese dumping and closing their markets to our silicon chips, but basically there seems to be a consensus right now that we are falling behind in the development of our own super chips.

Do you see any relationship between the supercomputer centers and working in further developing the American microchip industry? I mean, is there a relationship between the development of these centers through Government funding and helping America stay on the cutting edge of development?

Dr. **Lester**. Well, there can be, but a rather indirect one, I would think. I think the primary province for the aspects of development of microchips and various chips of one sort or another revolves around industry per se. It is in the collaborative aspect of university researchers and industry coming together where we might see breakthroughs in that regard. I don't see that as a primary province where supercomputer facilities can themselves assist directly.

Dr. **Sugar**. Although I would say not just the supercomputer industry but also some of these smaller more innovative machines that I was talking about, the array processors and the hypercubes and such, have demands for the most advanced chip design and so forth, and they do help stimulate the chip industry and push it towards really the leading technological edge.

So, to the extent that we really try to push in these directions, I think we do help. It is a second order effect. I agree with Dr. Lester.

Mr. **Buechner**. Thank you. Thank you, Mr. Chairman. That is all the questions I have.

Mr. **Walgren**. Thank you, Mr. Buechner. Mr. Mineta.

Mr. **Mineta**. Thank you very much, Mr. Chairman. I am really pleased to have this panel here, with at least, I think, two out of the three either both having been residents of Santa Clara County, an area that I am from, both Mr. Roberts and Dr. Lester.

I have to say with regard to Louisiana education, that my faith in Louisiana education was restored because I have a staff person from LSU. We can turn the tables.

I would like to get into this whole issue of ability of—a follow-up on Mr. Hayes' question—mini supercomputers, whether that takes away from the supercomputer centers or does it actually give ability for more access? From what I understand that you are saying, we ought to do more networking and there ought to be more access.

The question is does it have to be at the supercomputer center? What about these mini supercomputer centers that seem to be coming up on their own? Is there a second level of coordination that we are going to have to be doing somewhere through NSF? Is the Directorate at NSF capable of dealing with this?

Dr. **Sugar**. May I try? I think I tried to say I believe there needs to be a balance in facilities. There are now on the market mini supercomputers, some of which, for example, mimic the CRAY and in fact use the same instructions. You can develop code on them and run it on them and then you can take it and run them on the supercomputer centers themselves.

In fact, the San Diego Supercomputer Center was donated one such machine. Those add, it seems to me, to the capabilities of the supercomputer centers, they add to the general program.

There are other specialized machines, such as array processors, which also add to the effort. They are specialized. They are ordinarily much more difficult to use than supercomputers. They are only good for very specific problems, but for those problems that they are good for, they are really wonderful. They are more cost effective than the supercomputers, for isolated problems. They don't detract in any way from the supercomputer centers. They add to the overall computing environment.

I think it is very important that we keep a balanced program, that we have all of the systems available. Some of the specialized machines, it seems to me, are not appropriate for the supercomputer centers because they are not really for the general computing population. They take very specific and long software development before they can be used and then you want to take your program and run it on it for months.

Those are better off in the hands of small groups who have very special needs for them. Again, it takes those groups off the supercomputers and makes that time available for others.

What we need is a mix and these things, in fact, I believe, will help each other and reinforce each other and make a stronger general program.

Mr. **Mineta**. Dr. Lester.

Dr. **Lester**. I would like to echo those sentiments but add another dimension to them. Namely, that it is tied into the aspect of my testimony I did not read dealing with the difference between capability and capacity. One can have a lot of machines, super mini's, which provide capacity, the ability to get cycles out of your machines, whereas the aspect of being able to turn around a big job on a daily basis which might be a measure to some extent of whether or not projects are undertaken is tied intimately to the aspect of capability.

Is the machine large enough that indeed, in terms of a state-of-the-art project, that you might wish to undertake, and you think about doing it feasibly on a human dimension, and that is intimately tied into the capability of the machine of interest? That's where the supers come in.

I don't believe they are in conflict with the mini's and super mini's and so forth, because those machines costing less in many instances can be obtained by scientists. Indeed, I know the Chemistry Division at NSF does support the purchase of these machines certainly on a cost sharing basis. That is going on hand in hand with the supercomputer capability—I'm sorry, the supercomputer initiative and centers.

It is important to recognize that distinction, because I think it has clouded the issue over the years, that a number of years ago when the VAX-11780 first came out, people thought that indeed one didn't need supercomputers. My thought, having been in industry, in a situation where I had unlimited computer time on the largest machines then available, I could appreciate that in a very short period of time people would come to realize that they needed more capability. I think they are not in conflict and one needs both.

Dr. **Sugar**. Yes. Can I second what Dr. Lester just said? I think this is an extremely important point. If I tried to run a problem on my VAX, it will run generally several hundred or 500 times slower than on a supercomputer. In almost any problem that I have ever been engaged in, you need to interact with the computer. You do a run. You see what the results are. You see how you have to change things, how you have to change the parameters to look at it better, to look in the directions that you want to go.

If one run is taking months, as it might on a VAX, you obviously can't do that. The turn around time is so slow that you will never get finished. Those are the types of problems that you need to run on supercomputers because they will reduce weeks and months runs to a few hours runs. Therefore, they will allow you to complete programs that you simply cannot do on a VAX.

On the other hand, you should also be careful not to use the powers of the supercomputers to run programs that really can be run on a VAX or comparable machines, because that is extremely wasteful of these facilities.

Mr. **Mineta**. Who makes that determination?

Dr. **Sugar**. That determination should be made both by the individual scientist who should have the sense to know where to run, but it also should be made by the peer review committees who decide who gets what time on the computers. If I want to get time at the supercomputer centers, I have two choices. One is I can submit a proposal to the National Science Foundation and indeed, if I want to have large blocks of time, that's what I must do. If I want to get smaller blocks of time, I can submit proposals directly to the supercomputer centers.

In either case, as I understand it, these proposals are peer reviewed so that there are sensible decisions made as to who gets time on the machine. It is a very important aspect of the program.

Mr. **Mineta**. Is there criteria, standard criteria, for all of the five centers? Can a person go shopping for a form that might allow time on their supercomputer?

Dr. **Sugar**. Well, of course, when one applies for the large blocks of time with the National Science Foundation, that is completely standardized. To be quite honest with you, having had only the experience with the San Diego machine, I think I know what their criteria are. I would be very surprised if there were significant differences between the standards applied by the different centers, but I really am not the person who can fully answer that question. I would be surprised if there were major differences.

Mr. **Mineta**. The thing I am always afraid of is, as we have done in many areas, putting a lot of money into the capital development of machines and then there is no operational money available as these things come on line.

Do you see this as a potential with the standards that we have now? Or even if we wanted to expand, should we be thinking about where those resources might come from?

Dr. **Lester**. I think absolutely we should be thinking about the aspects of expansion and the development of the centers down the line in terms of the costs related to them. I think that there is clearly a cost savings in terms of critical mass, so to speak, in the sense of not necessarily building more centers but having those centers which are established be enlarged in terms of additional capabilities until such time as it does make sense to bring new ones on board. That is my sense of it.

Mr. **Walgren**. The gentleman's time has expired.

Mr. **Mineta**. Thank you very much to the panel, and thank you, Mr. Chairman.

Mr. **Walgren**. Thank you, Mr. Mineta.

Mr. MacKay.

Mr. **MacKay**. Mr. Roberts, I am a little bit embarrassed that I came in partway through all the presentations so I may be asking a question that has already been covered. It seems to me you raised in your testimony the issue that there are going to be networks, maybe networks that are highly useful because they have been coordinated between all the universities, and they may be national networks or, because things aren't moving rapidly enough, there may be a series of networks which are not coordinated, which sort of means at some point we will have to do it over again.

That is a different question, it seems to me, than the supercomputer question, and I would like to focus on that. To what extent do we have a problem in that the need in the user community is higher than our reaction time, and are we gaining on it and is the NSF giving, in your opinion, enough attention to this?

Mr. ROBERTS. I think, to be candid, you are seeing for the first time this year a separate budget for networking. I think we owe Dr. Bell considerable credit for having the vision to pull that out and recognize that over the long term, networking is important. It is a competing demand, and obviously, when you introduce new competing demands, you have pressures on the budget.

We have proliferation of networks here based on good intentions that have been overcome by advances in computing. I don't think there is any disagreement about that at all. There is considerable diversity of views about what to do about it and who ought to do something about it, and one of the principal points that I was trying to make today is it is essential that we form a partnership now to begin to attack those issues of what needs to be done and who ought to do it.

Now, Senator Gore, as you know, in the last session was quite interested in pursuing this line of thinking and work, and that ended up in the study which is being sponsored by OSTP. That study, however, is not broadly enough chartered, in my view, to attack the problem at the appropriate level. In my written testimony we have recommended that Director Bloch and the National Science Board undertake an examination of the breadth of the issues that ought to be taken under study at this time.

Mr. MACKAY. Are you saying, then, that we have a problem of paying too much attention to the state of the art hardware and not enough attention to the rather mundane problem of networking, and that the networking thing is going to end up being the ultimate strain?

Mr. ROBERTS. There was an assumption in the seventies that investments primarily by the Department of Defense in networking technology would bring that part of the puzzle along in an appropriate fashion, or possibly if that didn't happen, that the telecommunications industry would do this. I think as we sit here today in 1987 with a serious networking problem, neither of those things occurred, so we are in a reactionary, behind-the-power-curve situation in networking, as part of a general scientific posture.

Mr. MACKAY. I have the dubious honor of speaking for this Committee on the Budget Committee, so I look at things perhaps a little differently as a result of a couple of years of scars on that Committee; but there we are talking about trying to set priorities within the boundaries of constrained resources. Here we tend to talk about, is this good and is that good and how good is this and how good is that; but the real question that we end up facing is, if you can't do all of these things, where are the choke points?

What I am trying to ask you now is, since we have one person who is a specialist in that aspect and two who tend more to be users, all three of whom are at the state of the art, if we can't do it all, doesn't this provide a variation of the same problem that we had with the super collider? I mean is the choice between doing something big and flashy with another supercomputer or five more supercomputers at the price of not getting networking and then ultimately realizing that we have got to go back and do the networking; almost like putting in a road in the wrong place and having to do it over at a much greater cost?

I would like to hear the three of your views to see if you see this issue the same.

Mr. ROBERTS. I would just like to lead off by saying that we are dealing here with a relatively modest amount of money, and one of the points I would like to make at you, because committees tend to look at percentage moves in budgets, is there is a 35 percent move in this budget, and people say, well, how come these guys ought to have 35 percent?

Frankly, we are talking about a $3.5 million increase with a problem whose scope is considerably broader than that and it has a direct effect on other scientific programs where we are talking about budgets of hundreds of millions of dollars, not only in NSF but elsewhere in the scientific establishment.

Mr. MACKAY. The inability to transmit the data as rapidly as the computers——

Mr. ROBERTS. Yes, sir. And I think that there are two things, there. First of all, you want to aggressively pursue that line item, which is a somewhat controversial line item in the Foundation's budget, and if it were me, I would ask why shouldn't it be larger if you people are in trouble in this area?

Secondly, I think it is important that on behalf of the Congress you take a position that on a national basis, you really want to see some attention devoted to it. The telecommunications industry is mired in all kinds of problems associated with deregulation, and they have various very parochial and partial solutions to sell to this that have been a significant problem on our campuses.

Just to take the example of four institutions that you are hearing from this morning. If I may speak for my home institution Stanford, MIT, Michigan and the University of California, we are talking about investments currently in progress of over $100 million in those four institutions to deal with their priorities in this important area. So money is being spent out there on the campuses to attack the problem, and we need a more effective national focus.

Dr. SUGAR. I also think this has just got to be a high priority issue. It just doesn't do any good to create these centers and then not have proper access for the users. Otherwise, they won't be national centers, they will be local centers for San Diego and Illinois and Pittsburgh and Princeton. That is not, I am sure, what you intended. You have got a tremendous investment in the hardware quite properly made, and now we have got to bring the networking up to meet that. It has just got to be a very high priority, in my opinion, from the point of view of the users.

Mr. MacKay. Do you feel that the budget of NSF—I realize that, as Mr. Roberts said, it reflects a big percentage increase. Do you feel that it deals adequately with this issue?

Dr. Sugar. I am just not qualified to tell you whether this dollar figure or that dollar figure is the right one because I just simply don't have the expertise. What I can tell you is, from the viewpoint of the users, we really have to move forward in this area. Mr. Roberts is much better qualified than I to tell you what the right dollar figure is. What I do know now is we don't have in place the type of network that we need.

I appreciate that people have been working on this hard and that real progress has been made this year. There is no question about it. But we need to do more than we are doing.

Mr. MacKay. I realize. I didn't ask exactly the right question. I now see what the question is that I should have asked.

Mr. Walgren. And the Chair will let you ask it.

Mr. MacKay. Thank you very much.

If those four institutions are putting up $100 million, and being part of the national network may or may not be part of their goal in life, and we are putting up $3 million, then I suspect that I see what we are going to have, and it is not going to be a national network. In other words, if we are not putting enough money in this solution to impact it, then the national dimension is going to get lost. I can see that.

Dr. Sugar. I completely agree with you, sir.

Mr. MacKay. Thank you, Mr. Chairman.

Mr. Walgren. And even to the point where we are asking how much weight to give to this function as opposed to that function, you can look at the private sector and they are coming up with an awful lot of money for that function and we are coming up with a very little bit of money for that function, and that ought to be a real red flag.

Mr. MacKay. If I might, and I realize I have overrun my time, I would like to hear Dr. Lester on that point.

Dr. Lester. The networking dimension is a very important one, but we see going hand in hand the problem of saturation of centers themselves, supercomputer centers. So there is this critical dimension of balance. Just as you struggle with the budget dimension, one has to look very carefully at the whole aspect of networking.

I agree with Mr. Roberts that the amount of monies that are involved in networking currently are low and something really has to be done there, but one has to look at the overall picture so we will retain balance and don't overreact in one direction or another direction at this time.

Mr. Walgren. Thank you, Mr. MacKay.

The Chair recognizes the gentleman from Illinois, Mr. Bruce.

Mr. Bruce. At our last meeting we had testimony from Congressman Sabo concerning his Phase I computer facility at the University of Minnesota, and on February 11th they received word that that center was to be shut down two days later on February 13th, this month.

I wonder if any of you had anything to do with that decision. We have been talking about networking and long-range planning and saturation, and it concerns me that that kind of decision could be made and a Phase I center could be told that in two days they were off the program. How did we get to that stage, and in fact, did any of you have anything to impact into that decision, and what is your reaction? Can the Phase II centers handle the workload, and what do we do with the Phase I centers?

I would be happy to start with Dr. Lester.

Dr. LESTER. I had nothing to do with the decision-making with regards to the closing of that center. It was the case, though, that based on the monies available for the supercomputer program, there was only so much available, and the primary focus is on the so-called Phase II centers. Minnesota was one of the resource centers that were funded initially in Phase I, and which was held over in terms of additional funding because of the access to CRAY-II, which is a resource which was not available in the Phase II centers.

If there were more funds available, then something could have been done to keep it open, but it is an unfortunate circumstance that indeed that center has had to close in the meantime because it does have that kind of capability. I think it calls attention to the budgetary constraints that one is dealing with in the supercomputer program.

Mr. BRUCE. Dr. Lester, did you not make a recommendation to NSF concerning their budgetary constraints? We have been talking about this whole new networking program and the need for funds there. Did not anyone consider in this whole debate what to do with the Phase I centers?

Dr. LESTER. As I indicated, some of the Phase I centers, and particularly Minnesota, were carried over and funds were made available. I believe that was on the order of $1 million. Now, the management of the Minnesota center knew how much they would be receiving in this fiscal year, so I don't offhand see why, indeed, it occurred, that because they consumed all their funds, they were taken off line in a few months.

Mr. BRUCE. Dr. Sugar, did you have anything?

Dr. SUGAR. No, sir. I had no connection with that. I am not on any of the advisory committees to the NSF and I really don't have any information I can give you on that subject.

Mr. BRUCE. Mr. Roberts?

Mr. ROBERTS. No, sir, I have not been directly involved. As a manager of a large computing center, I must say it is somewhat unfortunate to consider turning someone's access off on 48 hours notice, and undoubtedly there was a glitch in the Foundation's procedure in this regard.

Mr. BRUCE. That is what concerns me. It just doesn't show a great deal of long-range planning, and now that you are all talking about networking, I just wonder what the next glitch is down the road in NSF. I am concerned that you did not have any input into that whole decision. Your panel was not consulted?

Dr. LESTER. We were not consulted regarding that decision as such, no. We did discuss the overall budgets for the forthcoming year before, that is, for the present fiscal year, and so had indications of what monies would be available for the resource centers and the Phase II centers.

Mr. BRUCE. How close do you think the Phase II centers are to reaching saturation?

Dr. LESTER. Some of the Phase II centers are very close, from our perceptions. For example, the University of California, San Diego center appears to be approaching that point, very close to it. There are indications that others are getting close as well.

Mr. BRUCE. And then?

Dr. LESTER. And then there is a need for additional capability at the various centers to handle the load that is coming. Again, as I indicated earlier, it is the case that increasingly more users are coming on board. Those who had smaller requests previously, I am sure, will be planning projects which will demand much more in the way of resource, so we see that force coming in in stronger vogue and will require increased network capability. These forces are marching hand in hand, requiring additional support to make the total effort progress in a reasonable way.

Mr. BRUCE. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Bruce.

Mr. Valentine.

Mr. VALENTINE. Thank you very much, Mr. Chairman. I just have one or two brief questions. I would like to ask this gentleman if we are faced, with respect to this suggested or proposed superconducting super collider, and as the gentleman from New York stated I suppose with enthusiasm, that project will depend on many things, primarily where it is to be housed or located.

Do you know of any plans by one of our overseas friends or competitors? I understand there is an instrument similar to this in Switzerland. Do the Germans, West Germans or the Russians or the French have any plans to construct such a magnificent contraption as this, insofar as you know?

Dr. SUGAR. Sir, with one major exception, the European machines have all been built by CERN (Center for European Nuclear Research), the joint European research effort in high energy physics. They indeed have under construction a large electronic accelerator at their main facility in Geneva. That machine, however, is not in any way comparable to the proposed superconducting super collider. To the best of my knowledge, as high energy physicists, they do not presently have plans to build a machine that is comparable. They are in the process of constructing this machine called LEP (Large Electron-Positron). My understanding is that is where their energies are presently focused.

Mr. VALENTINE. Given our fiscal restraints which we should have, even if we don't often show them, do any of you have an opinion which you would care to express as to whether or not it would be a more practical approach for us to spend what funds we have available for this in some concerted effort with our friends in Europe; add to funds which might be forthcoming from France and West Germany to build this type of facility together.

Dr. SUGAR. Sir, I would personally like to see that be a joint project. To be quite honest with you, however, I don't know what the practicalities of that are. If that could be arranged, it would obviously be advantageous.

Mr. VALENTINE. I yield to the gentleman from Florida.

Mr. **MacKay**. I would like to interrupt there. Do you know of any reasons, security reasons why the information that we are trying to seek with this super collider would cause us not to do something in international cooperation?

Dr. **Sugar**. Excuse me, sir. Did you say security reasons?

Mr. **MacKay**. Yes. Is there any reason that we couldn't publish the results of this research?

Dr. **Sugar**. No, sir. The research that would be done with this machine would certainly be basic research which one would assume would be published in the open literature. I cannot see any reason why there could not be a joint effort with our European friends.

I know that we exchange information with the people at CERN on machine building, on all natures of the results coming from these accelerators and results from these accelerators are all published in the open literature.

Mr. **MacKay**. One more question. Indeed, isn't this such a fabulous and strange frontier that it would be similar to the initiatives which we have made in space, where we have invested heavily and we have gotten to a place that much of what we have accomplished is now open for the world to see? Don't we have the same situation? Aren't we likely if we go it alone to invest billions of dollars which would really benefit people who have not made that much of an initial effort?

Dr. **Sugar**. I would think so, sir, but let me add a word of caution. I am a theoretical physicist. In speaking with my experimental friends who are the people who are most actively involved in planning this machine and who are much more knowledgeable than I am, they tell me that there are serious problems in trying to build the machine jointly. I would really suggest that you have before you—you get before you people who are more expert than I on this matter, because I am sort of winging it off the top of my head. I think you will get much better witnesses than me to testify on the details of this.

Mr. **Boehlert**. Will my colleague yield for just one quick observation? Dr. Sugar, as you are continuing your discussion of this, winging it, as you acknowledge, don't forget our friends to the north in Canada. I mean, everyone seems to focus on potentially the U.S. and European cooperation but we have some good friends north of the border that are very interested in this and perhaps, just perhaps, we might work out a cooperative arrangement.

Mr. **Walgren**. The gentleman's time has expired.

Dr. **Sugar**. It's true, sir. We also have friends in Japan who might also be potentially interested.

Mr. **Walgren**. Mr. Perkins?

Mr. **Perkins**. We have friends all over.

Dr. **Sugar**. Right.

Mr. **Perkins**. It is always good to be in a friendly environment, right? Dr. Sugar, in your testimony, you indicated, and I apologize for being late but I have read your testimony, you indicated, and I believe Terry was talking about it a little bit earlier, the saturation point in San Diego. I think Dr. Lester was indicating it earlier as well. It was rapidly being reached.

In conjunction with the networking that you are talking about, do you have a timeframe whereby we would see saturation being achieved at all the different centers?

Dr. SUGAR. It's very difficult to predict. My experience is that when you put a machine on line and you provide reasonable access to it, the growth and use tends to be exponential. Therefore, machines tend to saturate in very short periods of time. I think as the zero order thing that you need to do is to be very careful in reviewing proposals for these machines so that you run on the supercomputers only those projects which really need the capabilities of the supercomputers and you run on the minicomputers those projects which can be run on the minicomputers.

That, however, will not alleviate the need to expand the capacities to the centers. I'm sure that will be necessary in the future and to the not very distant future.

Mr. PERKINS. You said that in your testimony. Not very distant being what, three years?

Dr. SUGAR. Two to three years, I should certainly think, but that's a real guess, sir.

Mr. PERKINS. One more question. In terms of the networking that you are talking about nationwide, and anybody can jump in if they want to, how extensive is that going to be?

Dr. SUGAR. How extensive do the networks need to be?

Mr. PERKINS. Yes.

Dr. SUGAR. I believe that you really need to connect all of the major research universities to a national network and that's something at least 56 kilobyte lines and for the very large centers, T.1 or 1.54 megabytes per second lines.

Mr. PERKINS. Over what period of time would this take place?

Dr. SUGAR. Well, it ought to be in place right now, so that everybody could have equal access to the centers. You can't ask people to perform miracles. It ought to be done as soon as possible. You know, we have been talking today about the great importance of the networking. I don't want to get lost in the shuffle the fact that a lot of progress has been made in the past year. There has been set up a backbone network connecting the various supercomputer centers. Many of the major institutions in the country have been connected with very good communications to the supercomputer centers and people are using this network and other people are struggling along with very primitive connections.

What we need to do is bring those people that don't have first class access up to first class access. I guess I'm not in a very good position to tell you whether that is something that could be done in six months or you know, just how long that would take. I really don't know.

Dr. LESTER. I would like to comment on this dimension as well. The National Science Foundation's network is NSFnet, which primarily is a backbone. It is a case that the Foundation has supported regional networks. SURA, and I can't recall exactly what it stands for, SURA is one. MIDnet. I can't give the institutions involved but it is in the middle west. NYSERnet in New York State, for example. They are various regional networks which the Foundation has support monies to support.

I think we will see increasingly, as regions of the country become more interested in being directly hooked in, steps being taken to support regional networks that would hook into the NSF backbone.

Dr. Sugar. I might also add to that list the San Diego Supercomputer Center has in fact created a network, its own network linking in its various affiliates. All of these things are being done.

If I could go back to your first question, to add one step. I guessed two or three years for saturation. In order to meet that problem, it is important that one start to plan now, what are we going to do to meet the problems of growing use. We need to have the centers starting to think about that and planning about that now, not when full saturation actually sets in.

Mr. Walgren. The gentleman's time has expired. The gentlelady from Rhode Island, Miss Schneider.

Miss Schneider. I wanted to apologize for not being here while you gentlemen were delivering your testimony but I was trying to persuade 500 young students as to why they should pursue science, math and engineering courses of study so that they could be patriotic and help our country be more competitive. I think that's a fairly good excuse.

At any rate, Dr. Lester, I would like to know in your capacity as Chairman of the Advisory Panel, what your feeling would be in this era of much discussion about export controls and also discussions of improving our competitiveness base and threats by some members of Congress to increase the number of protectionist pieces of legislation that we are expending and "Buy American", what is your feeling insofar as how the NSF monies should be spent and if they ought to be used to purchase a foreign built supercomputer?

Dr. Lester. Excuse me while I reflect on that.

Miss Schneider. Someone behind you is in great pain.

Dr. Lester. Offhand, I don't see any reasons immediately to do so. This is one of the areas, the building of supercomputers, that the U.S. has done an outstanding job in. Insofar as learning about the technologies going on elsewhere, I think our industrial base is able to do this. It is a very competitive dimension and offhand, I don't see any reasons why we need to buy one for U.S. users at this juncture.

Miss Schneider. But we have the capability to produce our own?

Dr. Lester. Yes; we do.

Miss Schneider. I am not going to take up too much time because we want to move on to the next panel.

One of the questions—what would happen if one of your centers were offered a computer by the Japanese who are designing and constructing computers quite advanced also?

Dr. Lester. Did you say what would happen?

Miss Schneider. Yes.

Dr. Lester. I think they would accept it.

Miss Schneider. Can't look a gift horse in the mouth?

Dr. Lester. Yes.

Miss Schneider. My other question had to do with the level of industrial support. Some of the other members got close to asking this question but I would like to know specifically what you see as the reason why there has not been more industrial support for the centers? Then the second part of that question is what specifically can we do to remedy that dilemma?

Dr. LESTER. I don't think I have any real answer to that dimension, aside from the following: In my experience from the past, as Director of the National Resources for Computation in Chemistry, it is the case that the major companies, when they require supercomputer capability, as I was told then and I think still is the case, they go out and buy what they need. This aspect of cooperation means, from my perspective, the involvement of industry at a somewhat smaller level, at smaller companies, that for one reason or another don't see it in their capability to purchase supercomputers on-site at a given time.

For that reason, I think in time we will see as companies have the needs and as they see the possibilities associated with the use of the centers, see companies come in of a certain size and be so involved. I think they have to see what potentially might become available. In that respect, on the part of the Foundation and the centers, there is that dimension of conveying to industry what the prospects might be.

Miss SCHNEIDER. You have just hit on, I think, one of the most critical issues that consistently comes before this Committee, and that is information transfer. It seems to me from what you are saying, and you must correct me if I am not reading this appropriately, it seems to me there are a number of businesses that could be interested and enthusiastic about using those centers, if they only knew about them or if they knew what would be involved.

I find that here, our Committee has knowledge of all kinds of technology, everything from recycling and reusing 75 percent of our hazardous wastes, but the Governor back in Rhode Island doesn't know that and some of the other industries don't know that, so this information transfer is what is slowing down, I think, the consumer aspects of using some of our technology.

Is there any plan afoot on the part of NSF or on behalf of the centers to communicate this information and really try to drum up some business and involvement on the part of the industrial sector?

Dr. LESTER. All of these centers have been involved very much in making contact with industry. I think the key issue is the magnitude financially of their involvement. That has not been as large as ideally the various centers might like. If you look at the roster of companies that are associated with the various facilities, they look very good. They are the ones we would expect to see involved plus others. They have made equipment available.

From the perspective of hard dollars being made available to the centers, it has not been of the magnitude, for example, as I indicated in my testimony, to pick up the difference between what the cooperative agreements implied versus what was actually made available, for a variety of reasons, again.

Miss SCHNEIDER. Thank you very much. Thank you, Mr. Chairman.

Mr. MACKAY [presiding]. I would like to thank the three of you on behalf of the Committee. This has been excellent testimony and very thought provoking. I think you can see from the questions and the length of time that we have spent on this that what you have had to say is very central to the questions we are trying to puzzle through. Thank you very much.

Dr. SUGAR. Thank you very much, sir.

Mr. MACKAY. Our next panel will be Dr. Paul Gray, President, Massachusetts Institute of Technology and Mr. Richard Case, Vice President for University Relations, IBM Corporation.

We are running behind time. That is the dilemma we always face when we get into topics that are as broad and state-of-the-art as these topics.

I would like to ask both of you gentlemen if you can summarize your testimony. Your written testimony will be part of the record of this hearing. It is of course a matter of great interest to us. If you can summarize your testimony, it will leave more time for us through dialogue to really discuss the topics.

We have a terrible time staying within our own time constraints so I certainly understand a witness having that same kind of problem. With that very gentle admonition both to us on this side of the table and the witnesses, I will ask, Dr. Gray, if you will lead off.

STATEMENT OF DR. PAUL GRAY, PRESIDENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS, AND MR. RICHARD CASE, IBM DIRECTOR OF UNIVERSITY RELATIONS AND TECHNICAL PROGRAMS

Dr. GRAY. I am Paul Gray, President of the Massachusetts Institute of Technology. I am a Past Member of the White House Science Council, and I am presently Vice Chairman of the Council on Competitiveness.

I am pleased to have this opportunity to speak to the subcommittee from an academic perspective on the role of the National Science Foundation and basic research in enhancing our ability to compete successfully in world markets.

I shall also comment on the question of participation of scientists and engineers from foreign countries in NSF-funded projects at our universities.

Before beginning this requested summary of my comments, Mr. Chairman, may I say I was delighted to hear of the recent formation of the Congressional Caucus on Competitiveness which you and several members of this subcommittee helped to get started.

Mr. MACKAY. Representative Schneider and I of the House cochair it, so you see—oh, boy, that's right.

Dr. GRAY. Let me state at the outset the threat to this nation's ability to compete in the international marketplace is serious and has multiple contributory causes. I would mention three.

First, the wholesale deterioration in the quality of public secondary education, particularly as it relates to science and mathematics.

Second, the Administration's policies and program cuts that seek to erode support for education and in some areas basic scientific research.

And third, an anti-technology attitude that permeates much of the public, including many in government. For most of this century, up to the past decade or so, the United States has been a leader in the introduction of desirable new products, processes and services into the economy.

Much of that leadership was the result of decades of productive work in basic areas of developing knowledge. Since World War II, that work has been supported largely by federal funds with the NSF in a starring role. It is indeed basic research in science and engineering, much of which is performed in American universities with support from the NSF and other federal agencies that has generated most of the new and fundamental knowledge upon which applied technology is ultimately built.

Examples abound from such breakthroughs as semiconductor electronics, electronic computation, high performance engineered materials, and the new and expanding field of biotechnology.

While there have been healthy increases in federally supported R&D over the past few years, support for basic research has not kept pace. Given our need to build the fundamental scientific base for future applications in technology, the proposed plan of increases for the NSF makes eminent sense.

I believe the proposed NSF increase should be considered a national priority and it should be authorized.

Another concern related to funding priorities is the growing emphasis on defense-related research programs, now over two-thirds of the total federal R&D budget.

Today's government needs to recognize that many of the benefits of university research have arisen from the opportunity for faculty and research staff to address a wide variety of fundamental questions in science and technology. The devotion of a large portion of the federal research budget to defense-related work runs the risk of displacing funding which supports other important areas of research.

While this trend may now be less evident in universities, it is cause for concern, for such shifts may draw talented people, including students and faculty, away from other promising lines of inquiry.

The university has traditionally been one of the primary sources of creative thought in society. As I have said in testifying previously to this subcommittee, creative thought does not in itself ensure the transfer of discoveries and inventions to society in a meaningful way. It is therefore essential that we develop cooperative activities between basic research institutions and industrial organizations that will assure both the rapid and effective transfer of new technologies.

In recent years, other nations have not often seized from us positions of scientific leadership, but they have often succeeded in superior development and implementation of the technology.

Effective collaboration with industry is an important characteristic of the contemporary research university. One example of this new focus is the—was the establishment by the NSF two years ago of university centers devoted to specific areas of technology, such as the one in biotechnology at MIT, in which the research, by design, involves representatives from both relevant companies and university personnel.

The NSF is now proposing to extend the development of multidisciplinary science and technology programs modeled on the existing engineering research centers. I believe the present NSF proposal to increase significantly its support of traditional basic disciplinary research is also desirable.

There is today, more than ever, the need to recognize and support individual researchers, as well as research teams who are working on the speculative edges of their fields.

Let me turn to a second special and significant characteristic of the modern U.S. research university, the coupling of education and research. Much of the strength and vitality of American higher education derives, I believe, from students and faculty participating together in the activities of the research laboratory, as well as the classroom.

The foundation proposes to increase the number and support of national fellows, of graduate assistants and postdoctoral associates. This is a most welcome step, for we need to recognize the dual role of students, undergraduate as well as graduate, as both learners in the traditional sense and as junior partners in the research enterprise.

Finally, Mr. Chairman, I have been asked to comment on the participation of scientists and engineers from foreign countries and NSF-funded projects. There is concern that we lose some of our competitive commercial advantage because foreign visitors, particularly Japanese visitors, are very active in participating in U.S. university projects because they take the knowledge back home with them.

But the benefits flow both ways, for we also learn a great deal from these visitors, who bring to these programs their own prior experience and knowledge, and who contribute importantly to the progress of our research programs.

It is my conviction that as a general rule, foreign researchers bring to our NSF and other university projects about as much as they receive, for creativity and innovation come with a variety of passports.

In sum, rather than restraining foreign access and foreign contributions to NSF and other university research, we need to do more to encourage U.S. companies to become more connected to our universities so that they might exploit more effectively opportunities for enhancing their competitiveness.

The federal government also needs to encourage and provide incentives for that kind of interaction. The NSF Engineering Centers program is one such example, and a good one. But we need a greater number of cooperative research programs involving government-industry-university collaboration.

Beyond encouraging closer interactions with U.S. universities, we also need to reach out to find out what is happening abroad. How about more support, for example, for foreign language training, especially Japanese? We have a program at MIT where we are training engineers and scientists in Japanese, and then sending them to Japan for internships in corporations and universities. There are only a handful of such programs in the country, and the total number of U.S. citizens involved is shockingly small.

In conclusion, a strong competitive posture requires continued strength in the research universities, where the ablest minds in the world have the freedom to learn and to create, to push out the frontiers of knowledge, and to educate the next generation of scientists and engineers.

Our universities enjoy a great competitive advantage in these respects, as many foreign observers have testified. That advantage must be preserved and enhanced.

We must at the same time facilitate the transfer of new knowledge to and the development of new business opportunities in American industry for the benefit of both this society and the world economy.

Mr. Chairman, that concludes my statement.

[The prepared statement of Dr. Gray follows:]

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

HEARING ON NATIONAL SCIENCE FOUNDATION AUTHORIZATION
February 25, 1987

Statement by

Paul E. Gray
President
Massachusetts Institute of Technology

Mr. Chairman, Members of the Committee:

I am Paul E. Gray, President of the Massachusetts Institute of Technology. I was formerly Professor of Electrical Engineering at M.I.T., and I serve as a director of several technology-dependent corporations. I am a past member of the White House Science Council and am presently Vice-Chairman of the Council on Competitiveness.

I am pleased to have this opportunity to speak to the Subcommittee, from an academic perspective, on the role of the National Science Foundation and of basic research in enhancing our ability to compete successfully in world markets. At the conclusion of my remarks, I shall also comment on the question of the participation of scientists and engineers from foreign firms in NSF-funded projects at our universities.

Before beginning my formal testimony, may I say that I was delighted to hear of the recent formation of the Congressional Caucus on Competitiveness, which the chairman and several members of this subcommittee helped to get started. I am particularly pleased that Claudine Schneider, a friend from New England, and Buddy McKay are the two House co-chairs. I salute this important initiative and would be pleased to do anything I can to assist it.

Turning now to my testimony, I want to state at the outset that the threat to the country's ability to compete in the international marketplace is serious and has multiple contributory causes. The bestiary of suggested or alleged culprits is immense. They vary all the way from currency exchange rates to questions about managerial effectiveness. For my own part, I would mention three:

1. the wholesale deterioration in the quality of public secondary education, particulary as it relates to science and mathematics;

2. the Administration's policies and program cuts that seek to erode support for both education and, in some areas, basic scientific research;

3. and an anti-technology attitude that permeates too much of the public.

In any event, it is clear that our competitive edge has been dulled.

For most of this century, up until the past decade or so, the U.S. has been a leader in the introduction of desirable new products, processes, and services into the economy. Much of that leadership was the result of decades of productive work in basic areas of developing knowledge. Since World War II, that work has been supported largely by federal funds, with the NSF in a starring role. The rationale for this support has been grounded in a variety of arguments, of which the most important is the conviction--broadly shared--that basic research ultimately results in practical benefits for the society. That conviction, the record shows, is well-founded.

It is indeed basic research in science and engineering, much of which is performed at American universities with support from the NSF and other federal agencies, that has generated most of the new and fundamental knowledge upon which applied technology is ultimately built. Examples abound, from such breakthroughs as semiconductor electronics, which was my own special field; to electronic computation; to high-performance engineered materials; to the new and expanding field of biotechnology. Indeed, most of the technologies that create today's business headlines have grown out of the most fundamental kind of basic research in science and engineering.

Yet while there have been healthy increases in federally supported R & D over the past few years, support for basic research has not quite kept pace. Given the expansion and diversification of scientific knowledge, the growing complexity of research, and the expanding, international character of the research community, basic research is becoming more costly. And given our need to build the fundamental scientific base for future applications and technology, the proposed plan of increases for the NSF makes eminent sense. The spirit of the proposal springs from the recent report on "The Health of U.S. Colleges and Universities" which was drafted by a panel, on which I was privileged to serve as a member, of the the White House Science Council. I believe the proposed NSF increase should be considered a national priority and should be authorized.

Another concern related to funding priorities is the growing emphasis on defense-related research programs--now over two-thirds of the total federal R & D budget. It was the universities' involvement in defense-related work in World War II which sparked the government's full recognition of the value of university research. But today's government needs to recognize that many of the benefits of university research have arisen from the opportunity for faculty and research staff to address a wide variety of fundamental questions in science and technology. The devotion of a large portion of the federal research budget to defense-related work runs the risk of displacing funding which supports other important areas of research. While this trend may now be less evident in the universities, it is cause for concern, as such shifts may draw talented people, including students and faculty, away from other promising lines of inquiry. It is essential that the government's pattern of research support remain balanced in order to maintain our universities' remarkable record of broad-scale contributions to our society.

The university has been traditionally one of the primary sources of creative thought in society, and this fact is, of course, of transcendent importance. But as I have said in testifying to this Subcommittee before, creative thought does not in itself ensure the transfer of discoveries and inventions to society in a meaningful way. It is therefore essential that we develop cooperative activities between basic research institutions and industrial organizations that will assure both the rapid and effective transfer of new technologies.

In recent years other nations have not often seized from us positions of scientific leadership, but they have often succeeded in superior development and implementation of new technology. Thus stronger relationships that bridge between industry and basic research can be seen as matters of national interest to be encouraged and fostered by Congress.

With the passage of time, my convictions on this point have become only stronger. Over the past few years, intensified international competition and the accelerating pace of technical developments in many fields have only increased the importance of university-industry interactions in basic research activities. Experience has shown that these interactions not only strengthen the industries involved, but they also enrich both the nation's general research effort and, on our campuses, the quality and relevance of our teaching.

Happily, effective collaboration with industry is an important characteristic of the contemporary research university. Another special feature is the coupling of education and research, and I wish to comment briefly on each of these two qualities.

With reference to university-industry connections, let me observe first that most of the examples of great technical developments I have mentioned grew out of both our strength in science and technology _and_ our capacity to see commercial potential in new knowledge and ideas. A great many of these successes reflect in turn the results of a partnership between higher education and industry, a partnership that the NSF has sought particularly to stimulate, with increasing effectiveness in recent years.

One example of this new focus on university-industry cooperation was the establishment by the Foundation two years ago of university centers devoted to specific areas of technology--such as one in biotechnology at M.I.T. In these centers, the research, by design, involves representatives from both relevant companies and university personnel. This program evolved, in part, from an earlier NSF-supported experiment designed to draw industry into close association with a university project. One such experiment at M.I.T., in polymer processing, after having been established with NSF support, was taken over, continued, and greatly expanded by the private sector.

The NSF, as we know, is now proposing to extend the development of new multidisciplinary science and technology programs modeled on the existing engineering research centers. This proposal, which I hope the Subcommittee will endorse, is entirely consonant with one of the major themes of the report of the White House Science Council panel to which I have referred and which called for a stronger partnership among the federal government, industry, and universities.

I believe the present NSF proposal to increase significantly its support of traditional basic disciplinary research is also desirable because the improvement of U.S. economic competitiveness will require a bolstering of our support of basic disciplinary research quite as much as the creation of mechanisms, such as the NSF centers, to facilitate the transfer of the fruits of new knowledge into the economic mainstream. I believe we must move strongly on both fronts, with constant care that we are maintaining a proper balance between these two quite different, but essential activities. There is today more than ever the need to recognize and support individual researchers, as well as research teams, who are working on the speculative edges of their fields.

Let me turn now to a second very special and significant characteristic of the modern U.S. research university: the coupling of education and research. American universities are unusual in the extent to which they combine the functions of education and research. In most other nations, these activities are separate. Much of the strength and vitality of American higher education derives, I believe, from the creative intertwining of these activities -- from students and faculty participating together in the activities of the research laboratory as well as the classroom.

The Foundation proposes to increase the number and support of National Fellows, of graduate assistants, and postdoctoral associates--and to do this in large measure through the program directorates. This is a most welcome step, for we need to recognize the dual role of students--undergraduate as well as graduates--as both learners in the traditional sense and as junior partners in the research enterprise.

Finally, Mr. Chairman, I have been asked to comment on the participation of scientists and engineers from foreign countries in NSF-funded projects. There is concern that we lose some of our competitive commercial advantage because foreign visitors, particularly Japanese, are very active in participating in U.S. university projects and because they take the knowledge back home with them.

It is true, of course, that there is an on-going involvement of researchers from Japan--and from other countries, too--in projects at our major research universities. And it's true that these visitors benefit from NSF-supported research at these institutions. But the benefits flow both ways, for we also learn a great deal from these visitors, who bring their own prior experience and knowledge, and who contribute importantly to the progress of our research programs.

It is my belief that, as a general rule, foreign researchers bring to our NSF and other university projects about as much as they receive. For researchers are obviously not selected by principal investigators at random, but for the positive contributions they can make. Thus the benefits derived from foreign participation flow both ways, for creativity and innovation come with a variety of passports.

In looking at this matter of foreign participation in NSF and other research activity at M.I.T. , a committee of our trustees at M.I.T., the majority of whom were industrialists, said this:

> "...the question arises as to whether foreign visitors are sometimes purposefully placed in schools such as M.I.T. to extract the latest commercially useful research within a field. This is part of a larger question that must then be addressed--namely, whether foreign companies are more effective in using such data because they

> seize the opportunity of access more forcibly than their American counterparts. If this is the case, the better response might be to encourage American corporate participation in a more effective way with the U.S. university research community rather than to discourage foreign company involvement with M.I.T. We do recognize, however, that existing U.S. laws regarding anti-trust inhibit the type of industrial collaboration that helps make concentrated effort by foreign groups so effective in these areas."

Rather, then, than restraining foreign access and foreign contributions to NSF and other university research, we need to do more to encourage U.S. companies to become more connected to our universities, so that they might exploit more effectively these opportunities for enhancing their competitiveness.

The federal government also needs to encourage and provide incentives for this kind of interaction. The NSF Engineering Centers program is one such example, and a good one. But we need a greater number of cooperative research programs involving government-industry-university collaboration. We need support for joint initiatives aimed at improving our manufacturing and industrial productivity. We need support for undergraduate, graduate and continuing education, encouraging U.S. companies graduate and continuing education, encouraging U.S. companies especially to place more emphasis on this crucial component of our overall educational effectiveness.

Beyond encouraging closer interactions with U.S. universities, we also need to reach out to find out what's happening abroad. How about more support, for example, for foreign language training, especially Japanese? We have a program at M.I.T. which trains engineers and scientists in Japanese, and then sends them to Japan for internships in corporations and universities. There are only a handful of such programs in the country and the total number of U.S. citizens involved is shockingly small. We clearly need more effort along these lines to increase our awareness of what's really going on in Japan, and in other countries, and to take advantage of opportunities for collaboration.

In sum, a strong competitive posture requires continued strength in our research universities where the ablest minds in the world have the freedom to learn and to create--to push out the frontiers of knowledge and to educate the next generation of scientists and engineers. Our universities enjoy a great competitive advantage in these respects, as many foreign observers have testified. That advantage must be preserved and enhanced. We must at the same time facilitate the transfer of new knowledge to, and the development of, new business opportunities in American industry for the benefit of both this society and the world economy.

Mr. Chairman, that concludes my statement. I would be pleased, as you might wish, to respond to questions.

PAUL E. GRAY
President, Massachusetts Institute of Technology

Dr. Paul E. Gray, a recognized leader in engineering education and university administration, became the fourteenth president of M.I.T. in 1980. He earned the S.B., the S.M., and the Sc.D. degrees in electrical engineering at M.I.T. and served on the faculty and in the academic administration, notably as associate provost, dean of engineering, and chancellor, before becoming president.

The author or co-author of numerous basic texts in the field of electrical engineering, Dr. Gray's professional interests are in semiconductor electronics and circuit theory. As a member of the faculty, Dr. Gray won recognition for his superlative teaching and for his contributions to the revitalization of engineering education. In recent years, he has been a leader in the continuing development and reshaping of the undergraduate curriculum in order to provide students both with a broad understanding of the contemporary world, including the impact of technology on human affairs, and with a thorough mastery of a specialized field of interest.

Under Dr. Gray's administration, the university has expanded its relations with industry, both in this country and abroad, and is developing major research and educational programs in such areas as microelectronics, health sciences and technology, communications, the brain and cognitive sciences, and the management of technology.

Dr. Gray is a member of the National Academy of Engineering, a fellow of the Institute of Electrical and Electronics Engineers, a fellow of the American Academy of Arts and Sciences, and a trustee or director of numerous educational, cultural, or corporate institutions. A former member of the White House Science Council, he is presently vice chairman of the Council on Competitiveness.

February, 1987

Mr. MacKay. Thank you for that very succinct summary. And we will now call on Mr. Case.

Mr. Case. Thank you very much, Mr. Chairman.

Before I begin, I'd like to thank you for the promotion that the committee apparently has given me. Somewhere the records got straight and I have not yet been elected an IBM vice president. The correct title on the testimony that I have provided is IBM Director of University Relations and Technical Programs.

Mr. MacKay. Well, up here we are not very precise, and you're vice president for a day.

Mr. Case. Thank you very much. [Laughter.]

I have prepared rather lengthy testimony, and with your permission I will not—I will not read it, but I will just comment very briefly as to what it contains, and then we can proceed to the questions.

I am here today on behalf of the National Society of Professional Engineers, and a Joint Society Engineering Task Force, and we are here for the purpose of supporting the National Science Foundation budget proposals that are before you. And in particular we would like to draw your attention to three components of those proposals.

The first is the cross disciplinary research component which is growing in NSF budget proposals at a rate that is faster than the average, and we think that is appropriate.

Secondly, the industry cooperation with the research that the NSF is funding—we think that's an important component of the growing need for industry cooperation with the research universities in the future.

And thirdly, the component which is focused at revitalizing the educational process, all the way from the elementary and secondary school curriculum, and so forth, through the undergraduate and graduate education, and especially for the revitalization and refurbishment of the engineering schools' laboratories.

Our motivation for being here is economic competitiveness, but we don't think that is just a code word that will cause us to collect $100; and we fully recognize that economic competitiveness in the United States does not depend only or even in large measure on the National Science Foundation budget. Our economic competitiveness, of course, requires proper trade policies and proper tax policies and proper fiscal policies, and in sum, those are probably more important than the things that we are talking about here today. But I would like to mention that we believe that increases in the National Science Foundation budget here being proposed are consistent with proper fiscal policies in particular, and consistent with the need for the desire for a balanced budget, with which we share.

The third point that I'd like to make is that—is to just expand a little bit on the point of federal and private cooperation.

We are not here to suggest that the federal government bears this responsibility by itself. We believe that the private sector needs to contribute to that, and the—we believe that in substantial measure the private sector is contributing to it, and we are urging them to continue and, if possible, to expand their contribution.

IBM started a university/industry relationship, at least in the IBM Company, back in 1920, a good number of years before economic competitiveness got to be an issue, with a joint research laboratory with the University at Columbia University, and we have been involved in joint industrial and industry research for some time since then. Over the last three years we have given more than $150 million in grants to higher education, or grants to education, and we have sponsored more than $100 million in sponsored research in American universities. The National Society for Professional Engineers is very active at the junior high school level, in the MATHCOUNTS program, which last year reached about 750,000 junior high school students. And so all the way from the beginnings of the educational process to the ends of the educational process, and then in postgraduate work, we think there is proper scope for and a growing awareness of the need for industry and private sector contribution.

In this regard, then, I will just mention that the federal role of the—the National Science Foundation part of the federal role can only be considered as really seed money, and money to take some risks that can't be taken by other people in an economic basis; to create centers of cooperation, point the way for the private sector to join, and to point the way for the rest of the public sector at the state and local level to join, and to the extent possible, to ensure coverage—that is, to find out if there's any gaps in what's being done, and to begin to start those.

The total national involvement in research development and engineering is estimated to be about $125 billion a year, approximately 50 percent federal and 50 percent private, and the less than $2 billion a year budget of the National Science Foundation is not going to make any statistical difference in the—you know, in the total the nation spends as a part of the gross national product. But it can make a very substantial intellectual difference, and it is for that reason that we are in support of their budget increases.

Thank you very much.

[The prepared statement of Mr. Case follows:]

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

NSPE

Testimony of Richard P. Case

IBM Director of University Relations and Technical Programs

IBM Corporation

on behalf of

The National Society of Professional Engineers,

and

The Joint Society Engineering Education Task Force:

The American Society for Engineering Education
and its
Engineering Deans Council

The National Association of State Universities
and Land Grant Colleges

he National Society of Professional Engineers

on the

National Science Foundation FY'88 Budget

Science, Research and Technology Subcommittee

U.S. House of Representatives

Wednesday, February 25, 1987

1420 KING STREET ■ ALEXANDRIA, VIRGINIA 22314-2715 ■ 703/684-2800

Mr. Chairman and Members of the Subcommittee:

Good morning. I am Richard P. Case of the IBM Corporation. I have been employed with IBM for 31 years, beginning in 1956 as a technical engineer. I am now the IBM Director of University Relations and Technical Programs and am responsible for corporate policies and programs for financial support to education. I am also responsible for IBM's technical journals, corporate awards and technical recognition programs. I come before you today on behalf of the National Society of Professional Engineers (NSPE), a professional society of 75,000 engineers representing industry, education, government, private practice and construction. I am also here representing the Joint Society Engineering Education Task Force which comprises NSPE, the American Society for Engineering Education (ASEE) and its Engineering Deans' Council, and the National Association of State Universities and Land Grant Colleges (NASULGC). On behalf of those organizations, I want to thank you for this opportunity to offer our strong support for the National Science Foundation FY'88 budget proposals.

My purpose today is to address the increasingly important interaction of industry and academia, and the important role of the National Science Foundation in fostering this partnership. Mr. Chairman, during this testimony I will be referring to some rather specific initiatives in the NSF budget proposal that deal with engineering and scientific research and education, but I want to make this point up front -- the National Science Foundation is the lead Federal agency that supports basic science and engineering research and education, and as such is critical to this nation's economic health and ability to compete internationally.

For several years now, America's competitive edge has been declining.

This historic 100th Congress has taken the initiative to address this serious problem, and I applaud your resolve. Let's be candid. If we are to renew America's economic competitiveness, we have some hard work ahead of us. It's not an overnight job, but rather a long and arduous process. Much of the difficulty that the United States is experiencing in competing in the international marketplace is a result of U.S. fiscal, tax and trade policies. It is also the result of our underinvestment in research and education. A focus on the invigoration of our research and education base is an appropriate and necessary element in our multifaceted drive to restore our global economic competitiveness. This revitalization can best occur through the encouragement and strengthening of partnerships between our universities, Federal and state governments and industry. While certainly not the cure-all for this nation's economic health, such cooperative ventures facilitate the transfer of new technology from research laboratories to industry and ultimately to the economy.

American industry is very dependent on the scientific and technological resources available through our universities. In search of answers to extremely complex basic research questions, industry has in the past turned to the academic community to find the broad combination of talented individuals to fill this need. This ability must continue, and American industry recognizes this fact. Let me use IBM as an example. There we have been involved in industry/university cooperative efforts for over half a century. IBM's belief in the value of education to its basic business dates back to the 1920s when IBM founder Thomas Watson, Sr., established an Industry/University Joint Research Lab at Columbia University. Today, IBM continues this commitment to education through numerous programs of our own and participates in various ventures catalyzed by the National Science Foundation. In the last three years, IBM has provided funds for over 750 graduate fellowships in science and engineering and 300 special awards to science and engineering departments for new faculty development and the pursuit of innovative educational techniques. In sum, over the last three years IBM has contributed $150 million to education and sponsored research at universities at a level in excess of $100 million. That research includes three major initiatives in computer-aided design and manufacturing, management of information systems, and materials sciences. The computer-aided design and manufacturing research is based at 22 universities and 41 community colleges across the nation. Research in the management of information systems is being conducted at 13 universities, and materials sciences research is under way at 12 schools, also representative of all regions of the country.

Mr. Chairman, I cannot overemphasize the benefit to IBM of its affiliation and support for academic programs at the graduate, undergraduate and pre-college levels. But there is an important and vital role for the Federal government. The benefits of an adequately financed technical education system extend to all society. Effective programs require leadership, and the National Science Foundation has demonstrated its ability to launch and guide successful programs. Our ability to continue existing programs and commit to new ones will help insure America a strong base of qualified engineering and science professionals.

Indeed, it is the exchange of intellectual peers that is the key element of the industry/university partnership. Certainly the financial support that industry provides is critical to the success of the partnerships. A solid engineering and scientific base depends on an adequate, even state-of-the-art, equipment and facilities infrastructure. However, we have found that more important to this endeavor is the "human capital" involved. I call it brainpower versus brawnpower. People are the origin of new ideas that fuel technological developments. The industry/university partnership will continue to flourish through the interaction of academic and industrial researchers. This concept of hands-on partnerships is still a relatively young one. Historically, an industry/university partnership meant the company supported single-investigator research and at some later date, received the investigator's findings. In many cases, that type of partnership has been appropriate, but it is not always the optimal arrangement. The involvement of the NSF in initiating new cooperative ventures is helping to establish a new blueprint for successful partnerships.

The National Science Foundation's commitment to the growth of these partnerships and ability to serve as a catalyst for other cooperative efforts are widely admired by industry. Even in this age of budget deficits and restrictive government spending, the proposed 16.7% increase in the NSF budget from $1.623 billion in FY'87 to $1.893 billion in FY'88 is appropriate. NSF's plan to double its budget by 1992 exemplifies a commitment to long-term U.S. research and education efforts. We believe it is necessary to provide this level of increase even within the context of a balanced budget.

Let me address the proposed FY'88 budgets of the three Directorates within NSF focused on engineering-related activities. The Science and Engineering Education Directorate (SEE) budget would increase by 16%; the Engineering Directorate (ENG) budget would grow by 26% ($42 million increase); and the Computer and Information Science & Engineering

Directorate (CISE) budget would grow by 23% (a $26-million increase). Together, those three activities represent 31% of the total recommended increase in the NSF budget and demonstrate an on-going commitment to engineering-oriented research and education. In 1983, those three activities accounted for 14.1% of the total NSF budget. In 1988, they would represent 24.5% of the budget. This growth has been accomplished in concert with a moderate pattern of growth in the science directorates, and we applaud this increased attention to engineering-related activities within the NSF.

This growth curve in funding for these areas may seem dramatic to some, but in comparison with total Federal support for research and education, the increases suggested in the NSF budget proposal represent "seed money." Statistics compiled by the NSF Division of Science Resource Studies indicate that in 1985 the United States spent $74.6 billion on non-defense R&D, or approximately 1.8% of our Gross National Product (GNP). When you look at the $84-million increase represented in the three NSF directorates that I mentioned, it amounts to .1% of U.S. non-defense R&D expenditures. When you look at the NSF FY'88 budget proposal as a whole ($1.893 billion), it still represents only 2.5% of non-defense R&D expenditures in the United States.

Mr. Chairman, I'm not arguing that the entire burden for civilian research and development in this country should fall on the Federal government. I will, however, suggest that the proposed budget increases recommended for the National Science Foundation provide funding that leverages support from other sources and are warranted and necessary if this Congress is serious in its commitment to strengthening American science and technology.

I would like to focus the balance of my testimony on programs within the NSF Engineering Directorate, to offer my thoughts on the way these programs improve industry/university partnerships and the role the programs play in improving our national base of research and education. NSF's Engineering Activity has a FY'88 budget proposal of $205 million, up from the $163 million in FY'87. The largest chunk of this increase ($18.5 million) will be in the area of cross-disciplinary research.

I am delighted to see the increases that NSF is proposing for engineering education programs such as the Presidential Young Investigator Awards Program. I am happy to see the 85 new PYI awards. These awards encourage promising young faculty to continue their research careers and remain as faculty and, therefore, help to fill the alarming high number of vacancies in engineering faculty positions. Without enough qualified faculty, we jeopardize the quality of our engineering educational system. This individual research provides a vital service -- focusing on highly specific research questions -- and such research must continue. I applaud the proposed increase for engineering education related programs, particularly the $5.0-million increase in the PYI program, and the $2.0-million increase for the recently established Engineering Initiation Awards (EIA) program. These programs encourage additional funding support from industry and academia. The PYI program, for example, received outside contributions totaling $8.0 million in FY'86.

Perhaps the most dynamic programs in the NSF Engineering Directorate, affecting research and education, are the Engineering Research Centers (ERCs) and the Industry/University Cooperative Research Centers. These larger-scale, multidisciplinary research ventures need increased and long-term support. The ERC program was originated in 1985, with a goal of 25 Centers total. By the end of FY'87 there will be sixteen Centers operational, and the FY'88 funding increase would allow for five additional centers. Truly this program has caught the attention and imagination of industry and academia alike.

Competition for the ERCs has been intense. Dr. Nam P. Suh, NSF Assistant Director for Engineering, reported recently that in the first two years of the ERC program, the National Science Foundation received 244 proposals from 114 engineering schools requesting $3.5 billion in support. During the same period, NSF had only $31.7 million to spend on the ERC programs. Benefits of the ERC program can be seen as early as the application procedure. The process of submitting a proposal requires faculty and industry representatives to join together in planning their proposal. Important contacts are made, establishing the foundation for a future research center. Many industry/university partnerships have sprung to life even without being selected by NSF for an ERC. The process itself has proven to be a catalyst.

The IBM Corporation has been an active participant in four of the original eleven ERCs, and I want to touch briefly on some of the observations we at IBM have made as part of our involvement with the ERCs, which I believe are typical of other companies. Probably the most exciting part of the ERCs is the fact that everyone involved seems to benefit from the experience. When students learn what fuels the industrial process in the "real world" they are better prepared for future careers in those industries. Academic researchers are better able to understand what are industrial relevant areas of investment. And industry benefits by gaining new knowledge, the result of the research. The Centers have helped to build bridges between traditional areas of study, forcing participants to open themselves to a broader spectrum of engineering problems.

I believe this process will have a synergistic effect in the development of new frontiers of study. These are the immediate results of the ERCs; however, tangible results remain several years away. Without sustained Federal support to leverage funds, the ERC programs will be in trouble. The National Science Foundation should encourage ERC candidates to examine the gaps in research and to further consider research into innovative technologies of the future. If these Centers are to assist the U.S. in restoring our competitive edge, we must develop technologies ahead of our competitors, not behind them. Mr. Chairman, these Centers, as well as the Cooperative Research Centers, warrant the full increase recommended in the FY'88 proposal ($18.5 million increase over FY'87, raising the total commitment to those two programs to $51.5 million in FY'88).

In addition to the single-investigator research and the cross-disciplinary research centers, I want to comment on the NSF commitment to improving the education of our future engineers and scientists by supporting programs in graduate, undergraduate and pre-college education and in faculty development. The FY'88 budget proposal for the NSF Engineering Directorate includes new funding aimed at revitalizing the undergraduate engineering curriculum. This new initiative in NSF can once again serve as a catalyst for the university community to reexamine its teaching methods and work on new curricular designs. In a world where technology is moving ahead in great leaps, we desperately need to be preparing our future engineers not only to deal with today's technology questions, but to explore new and perhaps undefined areas. The time has come and gone when an engineer could study a specific facet of engineering and be prepared for a place in the engineering profession. Engineering students must be pushed to excel intellectually across engineering disciplines, and be ready to continue their education throughout their engineering careers. That is why I feel it is important at this time to reevaluate and update our undergraduate curriculum and teaching methods.

Finally, I believe that as we look to our future, we must look at the pre-college engineering and scientific pipeline. Our children, this nation's future leaders, are not faring well in math and science studies when compared with other nations' students. A series of recent studies at several U.S. universities concluded that U.S. school children from grades one through twelve rank in math skills last among the 20 nations studied. I fear, Mr. Chairman, that we are not adequately preparing our pre-college students with the necessary technical skills to live and work in our increasingly complex technical society. More programs like MATHCOUNTS, the math coaching and competition founded by NSPE for seventh- and eighth-grade students, are necessary. In existence for only a few years, MATHCOUNTS reaches almost 750,000 students annually. IBM's pre-college commitment includes the Demonstration Schools Program, which last year provided computer training for faculty from 84 high schools in California, Florida and New York.

At IBM Corporation, we feel that education of our youth is critical to our future success. We applaud the wide range of Federal programs designed to improve primary and secondary education and to maintain a favorable environment for student loans and scholarship programs. And I urge this Committee, and the National Science Foundation, to explore new means of improving our pre-college math and science educational offerings.

Mr. Chairman and Members of the Subcommittee, I appreciate this opportunity to come before you to talk about a subject that I consider of great importance. The FY'88 NSF budget proposal offers this nation new and expanding opportunities to improve our research and education base, to bolster our government-university-industry partnerships and, most importantly, to develop our most precious national resource -- our people. Well-educated, intellectually challenged people are our "human capital." They are our key to economic competitiveness in the global marketplace, and our hope for a secure and productive future for the United States. It all begins with a commitment to supporting basic research in engineering and science and in constantly upgrading our educational system.

The National Science Foundation is well-equipped to lead these several initiatives, and we wholeheartedly endorse the full budget proposal of $1.893 billion for FY'1988.

Thank you for your attention, and for the opportunity to come before you today.

Mr. MacKay. Thank you very much.

I would like to ask what I perceive to be a very basic question in this area, and it may be that your perspectives will be different on this. I'd like for both of you to consider this question.

The university/industry cooperation clearly is something that we need, and I very strongly approve NSF urging that kind of cooperation. Is there a danger when you do that, that it's going to skew our traditional research priorities in the sense that the partner who is putting up part of the money, say the IBM, has less interest in really far reaching, high risk basic research, than that partner might have in research leading to a conclusion that would perhaps add to the bottom line for it's own shareholders? And if so, how do you build in some mechanism to protect against that?

Dr. Gray. Mr. Chairman, if I may comment on that.

I think that we need to recognize that support of university research by industry is inevitably going to be selective in terms of the fields of activity, or the projects that industry would wish to support.

In many areas of basic research, particularly basic research in the life sciences, or in the physical sciences, there will not be the degree of common interest in the sense of deriving from this interaction a benefit which will encourage many corporations to support the work.

But in broad areas of basic research as they appear in engineering disciplines, or in the applied sciences, as generated in the engineering context, that mutual interest is there, and certainly our experience at MIT, going back now a very long time, is that industry approaches these relationships without the kinds of narrowness of concern or desire for a particular outcome that may lie behind your question. They tend to come at these relationships with a recognition that there needs to be a fair degree of freedom in the choice of subject, and in the direction of the work, and that one can look for general areas of applicability to industry's interest, but you can't direct the work in detail. We have had—it's coincidental that Mr. Case and I are here together on this panel, because we have had at MIT now for 15 years a program of research sponsorship in the computer sciences from IBM, and I've been involved three times in the negotiation or renegotiation of those five year contracts, and I must say that the IBM approach to that relationship has been one which recognized from the beginning that a good deal of freedom had to be left to the director of the lab for computer science, about how those funds were to be expended.

So we sit down once a year with a group from IBM and the leadership of the laboratory and talk about what's been done, and how the work is going to proceed in the next year. There's no effort to direct that in a specific or near term sense. It has been an enormously important resource to that particular laboratory.

I suspect that our experience with industrial support is probably greater in magnitude and infraction of our research effort than any of the other research universities in the nation. With very few exceptions, industry has approached those relationships with a rather open and not short term view.

Mr. Case. I can hardly do better than to just second what Dr. Gray just said. I will observe that numerically we spend—the IBM

Company spends at universities more money on unrestricted and unfocused grants than we do on sponsored research. Though I will admit that we're inevitably selective in some way, and that we do tend to sponsor things that we think will be aimed at science and engineering and technology, more than Greek poetry, for example. Not that there's anything wrong with Greek poetry, but that's somebody else's job to do that.

The other way in which we try to be cognizant, directly cognizant, of the concern that you had mentioned, is that we try in every case possible to be sure that research that we're sponsoring at universities can be placed in the public domain. That is, that it's publishable. That in itself helps keep us away from the immediate bottom line, profit motivated, or proprietary secret kind of thing, that would have the bad effects that you're suggesting.

Mr. **MacKay**. This one follow-up. If NSF moves more heavily into funding through centers, interdisciplinary centers, then through individual projects, does that then mean that the researcher is under greater pressure to—does that put the researcher who wants to do the basic research at a disadvantage, as compared to the researcher who is more into the direction of applied research or technology? In other words, does that in itself cause the very talented young person who is trying to decide which direction to go to feel that well, they've changed the way it's going to work.

Dr. **Gray**. Mr. Chairman, I would—my sense of that important question is that by itself, the encouragement, the development and encouragement and joint Federal and industrial funding of centers, NSF centers, does not cause that skewing or distortion of interest, as long as the support for the individual-investigator-initiated-grant remains accessible.

I look at our own situation, where we have an NSF supported center in the area of biotechnology and that attracts faculty and students whose interest is in the application of modern biology to production of pharmaceuticals or chemicals or indeed more broadly to alternative ways of producing fuels and foods. Those folks have a different interest from the start. Their colleagues in the biology department are more concerned with what happens at the level of the molecule or the cell, and as long as those folks who are concerned about the areas that are not coupled in some obvious way to an application more fundamental in nature, as long as those folks are able to find support as well for their work, we will see both a continual renewing of the basic science base on which applied technology is built and also an ability to carry those two activities on, side by side, in the institution.

Mr. **MacKay**. So you are saying it is up to us. If we don't keep putting in more money, then there is going to be a conflict?

Dr. **Gray**. Yes, sir. I think that if the centers were to come to be a major force in displacing individual funding of investigator-initiated requests, then we would have a problem; yes, sir.

Mr. **Case**. Again, I think Dr. Gray is exactly right but I would mention that from a statistical point of view, there is bound to be some appearance that the group or the center efforts are displacing individual researchers.

We have discovered that some topics need to have a bigger collection of intellectual talent in order to make progress than the individual researchers can typically apply. This is because either no one person or no small group of people can adequately address the scope of work that is required in order to make progress or because the cross disciplinary nature of the need is there. In the last few years, the National Science Foundation in particular has recognized that and has begun to establish some centers. They have done it in an environment in which they have not had to reduce on an absolute basis, the support for principal investigators, but as a percentage basis of the total budget since the prior centers has been zero, it has to reduce the amount to individual investigators.

If you find an individual investigator that comes before you and says, gee, 100 percent of the Science Foundation budget could be that way and it used to be that way and now it is only 83 percent or something like that, the statistics inevitably cause that.

I think the only solution is just to accept the fact that progress in a lot of areas, we believe, demands the center approach and demands the cooperative and cross disciplinary approach. I believe that can be done without substantially reducing the level of effort to the principal investigators and if that is true, then we can all win.

Mr. **MacKay**. Thank you very much. Mr. Boehlert.

Mr. **Boehlert**. Thank you, Mr. Chairman.

I would like to take advantage of your appearance and my position to have you comment on the Superconducting Super Collider. We are talking about a proposed Federal commitment of $4 to $6 billion. I would like from each of you in general your reaction to this proposed Federal commitment and more specifically, do you think it will have, if we proceed, a negative impact on the limited amount of funding we have for other Federally supported research?

I guess the third part to the question is should we be looking elsewhere for an even greater expansion of NSF funding than is now proposed over the next couple of years?

Dr. Gray, would you mind starting that and my education?

Dr. **Gray**. Mr. Boehlert, you don't need this electrical engineer to tell you once again that is both an important and difficult question. Let me tell you what I think I know about it.

We are seeing with respect to the Superconducting Super Collider and in other areas of basic science as well, astronomy is a good example, the tremendous increase in the cost of instrumentation, which is necessary if one is going to pursue the study of the physical world beyond the frontiers that are now accessible to us.

I do believe that the proponents of the Superconducting Super Collider are quite correct in saying that an instrument like that, an instrument of that capacity, is a necessary next step if we are going to press out of our understanding of subnuclear structure as well as our understanding of the origins in the universe. I think they are correct in saying that if the nation says no, this is a stage of pursuit of scientific understanding we are not willing to take, that will have an enormous demoralizing effect on the science community narrowly and on the world of science affairs more broadly.

I am acutely conscious as I say these things that the SSC represents in construction costs about one year of Federal investment in basic research in all fields and that it will represent an annual operating cost of somewhere between probably a fifth and a sixth per year of the present investment in operations.

I am also conscious that there is another long, and to various degrees, a meritorious list of other major investments in instrumentation and facilities that you folks have to look at, at the same time.

I guess I would say, trying to come specifically to the nub of your question, I guess I would say that I think it is important that this nation undertake that activity but that it cannot do so at the expense of that $6 billion a year investment in basic research that the Federal Government now provides.

For my taste, if it were to have to come at the expense of that investment, in terms of you folks who set the priorities and decide where the dollars are going to go, then it would seem to me that it would have to be deferred, if it came at the expense of the investment, the broad scale investment in basic research across all those fields.

Mr. BOEHLERT. Thank you.

Mr. CASE. I think the superconducting super collider is certainly a very expensive operation. If you consider the Science Foundation budget here today, we are talking about an increase of some $270 million, that won't pay the sales tax on the SSC. In the context of do we do that or do we do what we have been talking about in terms of the National Science Foundation budget, I don't think there is any question, we have to do what the proposed National Science Foundation budget increased.

I will note that the superconducting super collider needs for its successful design and operation, supercomputers. There is a connection to what we have been talking about here today. It is not entirely separate. Maybe more light-heartily, I would suggest that if the only motivation for doing it is the particular state in which it is going to be located, then we are not yet ready to do it.

After all that is said, I think in terms of the overall national priority, I have to once again agree with Dr. Gray, as I think it is important for that phase of science that this project be undertaken, it is not so clear to me whether it be under the time schedule which it has undertaken, that might be adjustable by a year or two, and it might be startable at a low level and then stretched out a little bit farther and not get all the benefits but not reap all the disadvantages either.

If it comes down to the point of whether we have to take this superconducting super collider out of everything else, then I have to vote with Dr. Gray and say let's don't do it.

Mr. BOEHLERT. My second question and it is directly related to NSF, the President, and I think the Administration. This budget pleased most of us in terms of the next five years, the request for the NSF, in terms of its budget.

My question of you gentlemen is this. One, can NSF manage it, you think? Two, can the university community absorb the additional funding that is requested?

Mr. CASE. I have not studied that question, Mr. Boehlert. I would guess, just on first principles, that the NSF with its currently constituted staff probably cannot manage the program that adds to its current budget, two times its current budget. You would not expect that to be true.

On the other hand, they might very well be the appropriate umbrella in which to insert the new office for the management of the superconducting super collider project. Really, I have not studied the question. I don't have an informed opinion.

Mr. **Boehlert**. Dr. Gray.

Dr. **Gray**. Mr. Boehlert, I said earlier that I had been a member of the White House Science Council for four years. In that capacity, I served as a member of the Panel on the Health of the Universities, which reported a couple of years ago. That group tried to look hard at the role of this nation's research universities in both education and research and tried to look at its state and its needs.

We concluded, and so recommended, that there needed to be, over the next interval of time, over the next decade or so, an increase in real terms in the support of basic research in the nation on the order of a factor of two, and that it is necessary both to undertake the research efforts that are necessary, that are possible, and that ought to be undertaken by this society and also to support those institutions in that terribly important dual role of education and research. I cannot emphasize that too much.

It seems to me that this initiative with respect to the NSF is an important first step in that process and the intention to double that budget over a five year period and to take a big bite at that this year, I believe, is tremendously important and I support it fully. I think that the university—the research community which is the recipient of those funds can indeed absorb either in one year or looking more broadly over the five year period that kind of expansion and support, particularly if some of that support is directed towards those great unmet needs of instrumentation and facilities, science facilities, which have been so desperately underfunded.

If one looks at the Federal support of scientific facilities in this nation, it is now in real terms at about five percent of the level it was in 1968. We are simply wearing out those laboratories. We are teaching students on equipment which is older than they are and which is not nearly up to date compared with what they are going to encounter when they go to work in an industrial laboratory. Those needs do have to be addressed. NSF, I think, is aware of that.

Mr. **MacKay**. Thank you.

Congresswoman Schneider.

Miss **Schneider**. I am having a rather difficult time trying to formulate my question, but what I would particularly like to get at is the role of business and the role of higher education, since we have representatives of both at our table, and since Congressman Buddy MacKay and I have both had the good fortune to serve as government representatives on the Business, Higher Education Forum, we studied the question of research and the U.S. Federal Government's investment in it.

Dr. Gray, you had made a comment in your testimony earlier that two-thirds of our research is currently being spent on defense. Now the question that comes to mind is that if we are talking about $4-6 billion for the SSC, and the question is we have a limited piece of pie and we are going to have to make some tradeoffs here, you are dealing in a world where you are assuming that that tradeoff will have to come out of basic research.

Is there anything that you, as one of the world leaders of the academic community, and Mr. Case, representing one of the most prestigious international companies, is there anything that you are willing to do to shift the Federal Government's focus from that two-thirds investment in defense research to more non-defense-related research?

You recognize the problem, I think, and where those pieces of the pie are becoming narrower. And if I mention in your presence, you know, Brown University, which had been investing in research in a number of different areas, now the professors are having to put more of their effort into the SDI project, not terribly willingly, but that's the only place the money is. And I notice that MIT is—my perception is that MIT is saying, well, the Federal Government is not giving us the money to do this research, so we will go and hustle that research money elsewhere, and as a result, you are going to Japan.

Now what kind of effort might you, as a member of the President's Council, as a member of the Business-Higher Education Forum, be willing to undertake to hustle the members of Congress and of the Administration and say, look, we've got to do—let's make some changes here. Two-thirds of our investment in defense research is completely unbalanced.

Dr. **Gray**. Congresswoman Schneider, I think that in understanding the implications of that fraction, two-thirds, it is necessary to be clear—and I know you are—but that the total pie one is talking about there is research and development and engineering, and the lion's share of that total pie indeed is controlled by the Department of Defense. And the other thing that needs to be said is the overwhelming share of that is on activities that come with the D and the E, with development and engineering, and not much with the R, with the research.

Miss **Schneider**. Right. Right.

Dr. **Gray**. I'm—I don't have right at hand the figure for DOD expenditure on basic research, of the kind of research that we're talking about in a university environment, but it is of the order of a billion dollars, maybe a little less at the present time, out of that $6 billion total, through all Federal agencies. And it is what, it's 1/30th, I suppose, a few percent, of the total DOD expenditure in the R&D aggregate.

I would like to see—let me back up and say that I think the Department of Defense historically, over the last 40 years in this nation, has been a rather enlightened sponsor of university basic research, basic research. That all came to an end in 1970, with the passage of the Mansfield Amendment. And the Department of Defense has only in the last few years begun to stick its toe in the water again with respect to support of basic research in the university setting. And I have tried to encourage that—that new entry, and I have tried to encourage both at the Pentagon and on—in the Congress, with members of the Congress, that that kind of support should be expanded.

I think that the DOD can be a significant and enlightened and appropriate sponsor of basic research in the university setting, and it is—we are talking here about a miniscule portion of the total amount that they spend on research and development.

With respect to SDI particularly, let me note simply that most of the SDI support at—that—if you look in the books for MIT, most of it is associated with the Lincoln Laboratory, a Federal contract research center, which we operate. Out of about $275 million of research on the campus in this academic year, something on the order of six or seven or eight million dollars of it is SDI—supported through the SDI organization. Though it is for the campus activity, at the moment, a rather small part of the puzzle. And I must say that for our faculty, at least, mostly in materials, who are working in the areas supported by SDI, they do not see this as a—as a diversion or as a—as an inappropriate pulling away of their interest from—from other more fundamental work. They believe that that support is right down the line of what they'd like to do, whether it were to come from NSF or DOD

Miss **Schneider**. One of the concerns, however, is that much of the research that is being developed—unfortunately, in the area I am more familiar with—is with oceanographic research. Much of it that is sponsored by the Department of Defense is now coming under the—being classified, and there are also studies which indicate that the number of the amount of research that is being invested now in the Department of Defense has far fewer offshoots in the—what's the word I'm looking for—in the non-defense sector now since 1970, than we had prior to 1970, and much of the justification for investments in things like the space program or in defense have always been, well, there will be commercial offshoots—that was the word I was looking for, commercial offshoots. But those have diminished significantly. And so it doesn't seem that that can any longer be used as a justification.

I am wondering in terms of the element of development in engineering that you are suggesting here is that if much of the research or the development and the engineering part is financed by DOD, then what control does the business community have then? And this is the question we are currently addressing with export control legislation, and The Wall Street Journal, just the other day, mentioned how we are reluctant to sell our supercomputers to India because we are concerned about the diversion of information from India to the Soviet Union, whereby we have many American companies—I think IBM included— saying no, no, no, we are hurting our own export trade capability.

So the question is what kind of bind are we getting ourselves in by allowing so much control to be given to the Department of Defense? Is that—I mean the numbers might not be there, but aren't you concerned that this is a growing trend? Numbers are increasing and, you know, my philosophy has always been preventive medicine. I see the writing on the wall, and I am afraid we are going down a path where suddenly we will say, oh, my god, what have we done, and then crisis management will have to come into play.

It seems to me that business and higher education now could be more forthcoming with some responses to this.

Dr. **Gray**. Congresswoman Schneider, my concern, as I tried to indicate before, is that we will—we will be led as a nation to misunderstand the degree of our investment in basic research as it is conducted in the university and as it is coupled to education by the fact that the total that we spend on research and development, broadly defined, has grown so rapidly and largely through infusions of new funds in the Department of Defense. And I think there is a risk that we will be—will be led astray in terms of how much investment we are actually making in basic research broadly defined.

I agree with you that the—it seems to me that much of the mechanism that we have established in the area of export control serves mostly to frustrate American corporations in their efforts to export products which are available from other suppliers worldwide——

Miss **Schneider**. Exactly.

Dr. **Gray** [continuing]. And contributes relatively little to our national security. I think that's been—that's an area in which the concern for secrecy or for limiting the distribution of equipment has been too broadly applied and not tied specifically enough to the reality of what is available elsewhere in the world.

Mr. **Case**. I don't know what more I can add. It is certainly true that export controls have many times seemed very frustrating and illogical. It's illogical especially against that the—against the reality of the modern worldwide marketplace, that if they're not available from the United States, they are available from others, occasionally the same equipment; and if not the same equipment, competitive equipment with specifications which are relatively indistinguishable as far as security is concerned.

Miss **Schneider**. Well, it just seems to me that we Members of the Science and Technology Committee have the responsibility to take the more comprehensive view, rather than the myopic view, and here we have two sectors being represented, and we constantly have to fight the battle and raise the question as to where these research dollars are going.

Now I have a little bit more knowledge base in the area of where the research dollars are going on the part of the Federal Government in the energy budget, and in the six years that I have been here, that trend has been incredible in that 53 percent of the energy dollars go to the Department of Defense. And out of one side of the mouth, the Congress or the Administration is saying we believe in the free market determination of what our energy policy will be. We don't support subsidies. But when you look—if the money is where the mouth is, it certainly is not; because the money that we are spending is being directed toward nuclear and fusion and fission and that sort of thing, to the exclusion of investments in energy-least efficiency, least cost-efficiency investments, and seven out of the 10 export markets that we have already lost have been in the energy markets—investments in ceramics, investments in motors, in refrigeration, in light bulbs.

So, you know, I see the big picture and it seems to me that the same thing is happening insofar as the defense priorities are concerned here, and we are just losing. And—but I don't see the business or academic community willing to stand up and say, well, Mr. President, we think we need to maybe, you know, take a different direction, and that's what is very discouraging to me.

So I don't have any other questions, but thank you for your indulgence, Mr. Chairman. Thank you for your responses.

Mr. MacKay. Mr. Boehlert has one final question.

Mr. Boehlert. Dr. Gray, the facility problem, how do we best handle it? Should we earmark funds specifically for facilities? Should we give more money to the centers and let them make the decision? How would you best address it? How would you advise us to best address the facilities problem?

Dr. Gray. Mr. Boehlert, the facilities question of how to distribute facilities money, if it were broadly available, is a difficult one, and it—I note that it's a question which the government found ways of dealing with, quite effectively, for a long period of time, through the 1950's and 1960's, right up to about 1968. There were——

Mr. Boehlert. It's been all downhill since then.

Dr. Gray. It's been all downhill since then, that's right; 95 percent downhill since then; 5 percent of 1968 figure now available in real terms.

And they managed to do that in a way which I think directed those funds wisely and effectively, and they did it through a process which involved reviews that focused on quality, just as the NIH or the NSF now distributes money to individual investigators, through a process of review, peer review and focus on who's got the ability and where is the quality. And I think that those funds could be distributed in the future in a similar way.

I would suggest that facilities funds are most appropriately allocated by the agencies, by the NSF or the NIH, by the agencies which have the oversight of the research program in its broadest terms. And in fact, one way of allocating those—those funds, one which—which—which ties them in a way to where the research activity is, is to— to connect it to direct activity through the indirect cost process. That is a—some would say that's a mindless way, but it does—it would allocate the funds in some proportion to where the research support, the extant research support is allocated.

Mr. Boehlert. Thank you very much.

Mr. MacKay. Thank you very much. This was an excellent panel, and we touched on the issues that are very central to the concerns that the subcommittee has.

We appreciate it.

Our next panel will be Dr. Harold Shapiro, President of the University of Michigan, representing the Association of American Universities; Dr. Joseph Goldstein, Vice President for Research at Lehigh University; and Dr. Sheila Widnall of MIT, representing the American Association for the Advancement of Science.

Good afternoon, lady and gentlemen. We very much appreciate your participation. I believe you have sort of heard the groundrules. To the extent that you can summarize, we will appreciate that.

I apologize for our continually declining numbers, but I can assure you that the quality is all still here.

Mr. Boehlert. I second that motion. [Laughter.]

Mr. MacKay. And we are very much interested in your testimony and want to take all the time that's necessary to be sure that we have your point of view on these questions, so if it's agreeable with you, we'll start with Dr. Shapiro and then Dr. Goldstein and then Dr. Widnall.

One of the ironies that we've been whispering about back here is that the Committee on Science and Technology does not seem to have the ability to get high tech microphones. You have to pull these fairly close to you.

STATEMENT OF DR. HAROLD T. SHAPIRO, PRESIDENT, UNIVERSITY OF MICHIGAN, ANN ARBOR, MI, ON BEHALF OF THE ASSOCIATION OF AMERICAN UNIVERSITIES; DR. JOSEPH GOLDSTEIN, VICE PRESIDENT FOR RESEARCH, LEHIGH UNIVERSITY, BETHLEHEM, PA; AND DR. SHEILA E. WIDNALL, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA, ON BEHALF OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. **Shapiro**. Well, thank you very much. It is a great pleasure for me to have an opportunity to appear before the committee on behalf of the Association of American Universities.

I have submitted written testimony. I think I will not read that, nor even summarize it extensively, in view of the shortage of time. I think I can summarize what it is that I have to say in a few very short declarative statements, which will reveal a little more certainty than I, in fact, feel. Nevertheless, they will make the point and I will leave the testimony to stand for itself for your consideration at another time and, of course, I would be ready to answer any questions you might have.

Let me just state my conclusions: First, that the strategy that the NSF is proposing for expanding the relative importance of research centers as a vehicle for research support is appropriate at this time, and I support that strategy. It is appropriate because of developments in science, and opportunities that would be available through that form of research organization that are otherwise unavailable. That's my first conclusion.

My second conclusion is that the expansion of research centers ought to be constrained by a number of factors which we ought to consider very carefully. That is, we ought not to expand them too quickly. There is a series of difficulties in ensuring the success of such centers, and I think that we ought to consider the current effort as experimental in nature and evaluate things as they go along.

Three, I think it is extremely important that these centers be asked to first suggest and then demonstrate just how they are going to engage in the overall educational effort of the universities within which they are being operated. It is extremely important, in my judgment, that the American research community within the universities continues this remarkable synergy between education and research. There has been too little focus on the enormous leverage that is available by the investment of public funds in such research centers and by ensuring that they have an impact on the generation—or on the production of the next generation of scientists and engineers. I think there has been too little focus on just how they are going to meet their share of the educational burden within the nation's universities.

Fourth, there is no way to answer the key question of just what the magic number is for the proportion of funding that ought to go to research centers as opposed to the more traditional vehicle of support, the individual—investigator—grant. There is no one, I believe, in this room or anywhere in this country who can tell you that 5 percent is the right number, 50 percent is the right number, or some other percentage is the right number.

We have to realize that we are engaged in a learning experience here, and we're just going to have to see how science develops, what the developments in science are, what the developments of potentials are, how successful they are, and so on.

Since we can not have a magic number, I think that oversight, which this Committee may choose to exert or the NSF itself might choose to exert, has to focus on process and evaluation. It has to focus on a process by which it is decided which areas of science are appropriate for research centers or could be especially helped by research centers. It has to focus on the evaluation of these centers. It has to focus on a number of process issues and ongoing evaluation, as opposed to trying to hit some specific target number like 30 percent, or 20 percent, or any other percentage that we might think about.

I think it's extremely important, whatever is decided in this area, that we not mortgage too much of our future. But we must retain flexibility, that we don't become engaged to some fixed set of centers and we find ourselves five or six years from now without any capacity to respond to developments which are certainly unpredictable at this time.

I am mildly supportive of the initiative. I think we ought to proceed with some care and with an assured method of evaluation over time, but also with some excitement. But nothing organizational, whether it be research centers or individual—investigator—grants, or some other type of organization of the research effort, is going to make up for the lack of adequate resources to fund the overall research effort in this country.

If we really want to be competitive—and that is a word that has been tossed around a good deal—we are going to also have to be competitive in the proportion of our national wealth and our GNP that we invest in non-defense R&D. It is just as simple as that. We can look smarter than a lot of other people, but we can not completely make up by organizational maneuvering for the lack of resource commitment both to the education of scientists and engineers and for non-defense R&D.

But I think the current initiatives—and certainly this Committee's efforts in the last few years—and the current budget for the NSF give us all reason for a great deal of optimism.

Thank you very much.

Mr. MacKay. Thank you, Dr. Shapiro.

Dr. Goldstein?

[The prepared statement of Dr. Harold T. Shapiro follows:]

TESTIMONY
PRESENTED BEFORE THE
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

AUTHORIZATION HEARING ON
NATIONAL SCIENCE FOUNDATION FY 1988 BUDGET PROPOSAL
FEBRUARY 25, 1987

HAROLD T. SHAPIRO, PRESIDENT
THE UNIVERSITY OF MICHIGAN
ON BEHALF OF THE
ASSOCIATION OF AMERICAN UNIVERSITIES

Mr. Chairman and Members of the Subcommittee:

I should like, at the outset of my testimony, to acknowledge the leadership of both this Subcommittee, its Chair, Congressman Walgren, and the current Director of the National Science Foundation, Mr. Erich Bloch. The Subcommittee has time and again demonstrated its thoughtful concern for the nourishment of U.S. science through, for example, its dedication to the continued vitality of the National Science Foundation (NSF). This dedication not only helps assure the future capacity of U.S. science, but plays an important role in ensuring that our country can meet the challenge of leadership in the next decades. Mr. Bloch, in his years as Director, has brought a new sense of vitality and public leadership to the Foundation. His views do not always coincide with my own, but he has always raised interesting issues, and under his leadership and with your support, the Foundation has played an increasingly important and useful role in the support of U.S. science. The American educational and scholarly communities as well as future generations--the ultimate beneficiaries of our work--owe an ongoing debt of gratitude to this Subcommittee and to Mr. Bloch for their leadership. We are, of course, especially gratified by the strong affirmation of the priority given to NSF by the FY 1988 budget request and the policy goal of doubling the Foundation's budget by 1992. The proposed expansion of the Graduate Fellowship is heartily welcomed by the nation's research universities and will, I believe, pay great dividends. Many other proposed initiatives seem likewise exciting.

As requested, however, my testimony focuses on one particular aspect of the National Science Foundation's evolving program--the appropriate role of research centers as a strategy or vehicle for meeting directly the needs of U.S. science and indirectly the broader economic and social needs of our society. This issue is currently being considered in relation to the more traditional vehicle of federal support for basic research--the individual investigator grant. In order to be as concise and terse as possible and, thus, meet the Subcommittee's eight-minute constraint, I will simply summarize my principal conclusions and list the areas of concern which I believe need to be addressed. I would, of course, be happy to respond to any questions from the Subcommittee and from its staff.

Principal Conclusions:

1. Increasing the share of the NSF budget devoted to the support of interdisciplinary and/or multidisciplinary research centers is--at the current time--an appropriate strategy to pursue.

   Comment

   My own assessment of contemporary scientific developments is such that I believe that a reasonable set of useful discoveries is available only through an interdisciplinary approach that would be difficult for an individual investigator to manage. In many fields we now require the merging of ideas, results and techniques from separate disciplinary areas in order to fully exploit our scientific potential. Evidence to support this view is already visible in many fields, and in these areas NSF efforts can be supportive and helpful rather than distorting and frustrating to both scientist and patron.

   The "call" for interdisciplinary and/or multidisciplinary research is as old as the formation of scientific disciplines themselves. Specialization has had overwhelming benefits, but it defined a new need to transcend these boundaries. Indeed, the challenges of cooperative work between the specializations of a single discipline are as great as the interdisciplinary challenge itself. The current NSF initiative, supported by similar efforts currently in place in many educational and research institutions is, therefore, part of a long history of concern with respect to these matters.

2. Given the challenge of using our scientific resources (human and physical capital) in the most effective way, given the difficulty of locating strong team leaders with both vision and disciplinary credibility, given the difficulty faced in project management by NSF, given the difficulty in establishing a congruence of vision between NSF and prospective scientific leaders, given the difficulty of deciding which areas can be effectively exploited by research center efforts and, given the difficulty of forecasting future scientific developments, the rate of expansion of the relative importance of NSF funding for research centers should be cautious, retain its flexibility, and be the subject of ongoing evaluation.

Comment

As a result of these cautions, I believe that NSF's initiative to expand in relative importance the funding of research centers should be constrained by the following considerations:

(a) Support for individual centers should be steady and predictable but time-limited. Organizations--as opposed to individuals--develop a bureaucratic capacity to sustain their support beyond their useful "lifetime." Greater discipline is requested, therefore, in terminating support at the appropriate moment. It would be extremely unfortunate if the Foundation gave up too much of its future flexibility by finding itself permanently "engaged" to a fixed group of centers. We especially need to avoid the trap of assuming that multidisciplinary efforts cannot be evaluated by experts in the component disciplines.

(b) In many fields, this form of organizing research efforts would not be appropriate (i.e., most effective), and careful thought needs to be given to selecting those areas of science which could be best assisted by this form of support. Further, in areas where such research centers would be effective, the optimal forms (e.g., extent of industry participation) will vary a great deal. We should, therefore, encourage experimentation with different multidisciplinary approaches.

(c) The need to ensure that these research centers can play their appropriate role in the education of the next generation of scientists and researchers.

Comment: The contemporary American research university is characterized by an unusually fruitful and highly admired joining of the conduct of research and the education and training of new scientists and researchers. It is essential, therefore, that these new research center initiatives indicate and subsequently demonstrate how they will meet their educational responsibilities. We need more focus on the potential synergy of such centers with both undergraduate and graduate education. We talk often of leveraging public research funds by also attracting private funds to such projects, but we often overlook the most important leverage available through the public support of research--the ability to use this support to enhance science education at many levels.

More broadly speaking, research centers that do not support the mission and values of the institution within which it operates will not prosper. In addition, it is critical to understand that the health and vitality of research centers cannot be sustained in a university environment which itself is doing poorly. The overall health of a "university" is yet one more factor needed for the success of a particular center. It is important, therefore, to structure these centers so that faculty loyalties to the university as a coherent, interrelated academic community are reinforced rather than undermined. If such centers are to have any reasonable chance of success, they must also build on and take advantage of the merit and reward system that presently exists within the scholarly community. Hopefully they will be a force for the appropriate evolution of the system rather than trying to proceed in a totally independent manner. Paradoxically, independence is riskier for a center than for an individual investigator.

Finally, I must acknowledge the importance of the Foundation's continuing efforts to strengthen science and engineering education throughout the educational system. The vitality of our nation's educational effort depends on the strength of the entire educational system (K-12, college, doctoral, and post-doctoral) and I fully support the Foundation's efforts to strengthen each of these components.

3. One of the foundations of the success of American science has been its openness and its well-developed communication channels. The values of the scientific community place great importance on both open communication and candid criticism. It is essential, therefore, that any research centers we might establish be firmly committed to these particular values. Too great a level of autonomy, too great a level of security, too great a level of insulation from open evaluation and criticism, too great a level of proprietary (i.e., secret) research could greatly undermine their effectiveness.

I would like to complete my testimony with a number of observations and a few final suggestions. The traditional source of strength of U.S. science and engineering research has been the individual investigator. This has not been an accident and I strongly believe that the individual investigator will continue to be the principal source of new ideas. In addition, I believe that the developing scientific agenda will be and should be primarily nourished from this source. Thus, the traditional grant program will continue to be the most effective source of new ideas for the foreseeable future and this needs to be nurtured and protected. Although the world of science and the nature of its supporting infrastructure have changed dramatically, the individual investigator program remains the environment most likely to sustain the complex amalgam of competition, intellectual humility, open-mindedness and risk-taking that is necessary for sustaining basic research. Individual autonomy and pluralism remain an enormous source of creativity in contemporary science. Finally, and most importantly, the long-term health of these centers absolutely depends on the vitality of the individual investigator community that surrounds it. The healthy interaction between these two segments of the research community is, I believe, an essential ingredient of the health of U.S. science.

In short, the social institutions that currently characterize the nation's research establishment have not been made obsolete either by the competitive economic challenges facing America or contemporary scientific developments. These institutions, however--including the research university--do require some modification. The current institutional arrangements do not represent the final and complete flowering of our imagination. Evolution, therefore, is more appropriate than complacency and in this context the NSF initiative in the area of research centers is to be welcomed as a useful experiment. But, when considering the alteration of an effective environment, we must guard against the seduction of replacing imaginative but disciplined thinking with rapid change for its own sake. The latter too easily gives the illusion that something important is happening.

Finally, one may ask how the Congress or the scientific community can be assured that the Foundation has struck a proper balance between individual investigator grants and research centers. Unfortunately, there is no way to answer this question with any great assurance. It is simply not possible to know in advance if research centers should occupy 5 percent or 50 percent of the Foundation's grant program. Oversight, therefore, must focus on the process of decision, pluralism of approach, flexibility, contribution to education and scholarship and open evaluation. We should understand how it is decided which areas of science and engineering could make most effective use of such approaches, and we should ensure some variety in approach, a capacity to reallocate resources easily and a commitment to education and careful evaluation.

The overriding goal of science policy is to assure that American science and the technology that both develops from it and supports it sustain our broad public purposes. These include national security, health, economic growth and competitiveness, the fuller realization of our individual potential and the maintenance of our cultural and civic life. Science policy in America, especially since World War II, has been remarkably effective in helping our nation pursue these goals. If this is to continue, there is one matter of overriding importance. We want to be more competitive in the position of our national wealth in GNP that we devote to non-defense R&D and to the education of scientists and engineers. In this effort, both the Subcommittee and the Foundation are currently demonstrating encouraging leadership.

rdg

Dr. Goldstein. Thank you very much for the opportunity to testify and to discuss the issue of balancing research funding between centers and principal investigators.

In my testimony, the written testimony, I have drawn heavily upon my university's experiences with operating a variety of research centers, one engineering research center, and with attracting a very high percentage of industrial support.

Because of the lack of time, let me come to my conclusions on the issue of balancing funding between large centers and individual research projects. This is a very complex issue, and what I would like to do is offer four principles which I think need to be considered. And many of them agree directly with Dr. Shapiro. We haven't talked about this at all, but they are very similar.

First of all, the center funding should be viewed as experimental with the potential for high payoff. The U.S. does not have a large amount of experience with center-type funding for cross-disciplinary research involving major industrial participation, and we need to wait to see how this experiment works out.

The second principle is, there is a continuing need for adequate government funding of these centers. If the center experiment is to have the best chance of succeeding, it must be adequately funded. It is unlikely that no matter how much industrial support we have, that that support will totally fund the long-term basic research that these engineering research centers are all about. And so from that aspect, it is important that the NSF and the Government continue to support these centers over the long haul.

Thirdly, individual project grants are in many cases as effective as multi-investigator activities in centers. Our experience shows that individual research projects develop excellent research results. And that means that we need not only to support research centers, but we need to continue to support what NSF has done so well in the past, individual—investigator—grants.

The fourth comment that I think is very important here, it is my view that now individual research projects are not funded at adequate levels of support. As the NSF has developed new projects, new programs, individual research projects are being squeezed for funds, and I can tell you that the universities are themselves ill-equipped to pick up the loss in funding.

One other quick comment that I would like to make, which is not exactly on the subject we were asked to talk about, is that as far as industrial leveraging is concerned with respect to the engineering research centers, we have seen a continuing trend to in some way evaluate the centers and their abilities to leverage outside funding. And I think that this is a very difficult issue, because different industries who participate in these centers have different capabilities and different histories in terms of supporting research funding within universities. And so when we make a judgment about how well the research centers are doing, let us talk about the basic science, the intensity of interest from the industries, and let us not be talking about how much money they are putting on the table.

Thank you very much for this opportunity to discuss some of the unique features of centers and individual research projects, and I welcome your questions.

Mr. MacKay. Thank you.

Dr. Widnall.

[The prepared statement of Dr. Joseph Goldstein follows:]

Testimony on

Balancing Funding between Centers and Individual Projects

Before the
Subcommittee on Science, Research and Technology
U. S. House of Representatives

February 25, 1987

J. I. Goldstein
Vice President, Research
Lehigh University
Bethlehem, PA

Introduction

It is my pleasure to have the opportunity to testify before you on the issue of balancing research funding between centers and principal investigators. My remarks will also consider the role of industry in supporting university research. In my testimony I will draw heavily upon Lehigh's experiences with operating a variety of research centers and with attracting an unusually high percentage of industrial support.

Lehigh currently operates over 15 research centers, including an NSF Engineering Research Center (for Advanced Technology for Large Structural Systems) and two smaller NSF Industry/University Cooperative Research Centers. NSF also supports a large number of individual research projects to the extent of 25% of our government funding.

With regard to industrial support, Lehigh receives over 25% of our grant support from industry. That level of industry support is about four times the average for U.S. universities. In addition, Lehigh is one of the four sites for the Ben Franklin Partnership Program, sponsored by the state of Pennsylvania.

This program fosters applied research projects between industry and universities.

Characteristics of Research Centers

Research centers at Lehigh and elsewhere vary greatly in terms of funding level, numbers of projects and researchers, organizational structure, and methods of interacting with industry. Typically an NSF Industry/University center involves a core group of five or more faculty. Lehigh's Engineering Research Center is much larger. This center, which is still in its first year, has 16 faculty actively working on the center's research.

Time does not allow me to discuss the wide range of center types. Therefore I want to concentrate on large research centers that are comparable in size and operation to an Engineering Research Center. I understand that the proposed NSF Science and Technology centers also fit this model.

The ERC's at Lehigh and other universities are comprised mainly of permanent faculty and graduate students who together do the bulk of the research. All Lehigh faculty also teach courses, which is an excellent way to introduce new ideas into the educational programs. There is also a small, permanent research and administrative staff. Visiting researchers from industry or other universities complete the roster.

The center performs basic, fundamental research of broad applicability and interdisciplinary character. The research is aimed at achieving major, long-term payoffs. The research is not for the purpose of short-term problem solving for industry.

Industrial advisory committees have a major voice in setting the center's research agenda, which consists of separate but coordinated research projects. Each project typically involves two or three faculty from different disciplines and a like number of graduate students. One faculty member may be contributing to several such projects simultaneously. Student seminars, research planning meetings, project newsletters, and other mechanisms are used to foster the exchange of information across disciplines.

A major advantage of the center is that funding is available for some items of expensive, specialized, multi-user research equipment. Examples include dedicated computer systems and large testing equipment. Another important advantage is a small pool of discretionary funds which can be used to initiate a few high-risk, high-payoff projects.

The transfer of technology between industry and the university is one of the center's major objectives. Since technology transfer occurs most effectively through person-to-person interchanges, the center encourages a variety of forms of industry participation. These include meetings with company representatives to identify research needs, plan new projects, and review progess on current projects. We encourage industry to collaborate on individual research projects, and to exchange personnel with the center. Participation in formal courses and short courses, shared use of equipment, and research reports are other forms of technology transfer. Possibly the best means of technology transfer is the movement of MS and PhD students, who do their research in the center, to industry.

The biggest contribution by industry is in helping to set and to perform the research agenda. Other industrial contributions include providing personnel, specimens and materials, access to specialized equipment, and direct funding to help support the center's activities.

Pros and Cons of Research Centers

The center mode of conducting university research offers a number of major advantages and strengths:

- It encourages faculty from different disciplines to work together to tackle larger problems.
- It encourages industry to work with the faculty in defining the research agenda, guiding the research projects, and in other activities.
- The national publicity given to the center attracts bright students to enter graduate school and apply their talents to significant interdisciplinary problems.
- The center, through its activities, conferences, and research, focuses national attention on major technical areas.
- It promotes creative new ideas by nurturing high-risk research, by encouraging interdisciplinary thinking, and by exchanging new insights with industry.

At the same time, there are some important, potential disadvantages to a research center, such as:

- Creation of a center raises expectations for quick progress to a high level. The center cannot solve today's industrial problems. The center works mainly through educating students and performing basic research, which are slow processes.

* The size of a center precludes many institutions from establishing one. The university must have a critical mass of faculty in all or most of the relevant disciplines before a new center is feasible. Many institutions may have only a partial faculty base.

* Creating a new center requires large front-end expenses. Major costs are incurred to develop the proposal and site visit. More substantial costs are new space, new faculty, fellowships and cost sharing.

* The center requires much higher administrative costs than for the same dollar amount of single-investigator research projects. Administrative costs include marketing campaigns to secure industry participation, programs to transfer technology, meetings of faculty to nurture interdisciplinary activities, and more sophisticated reporting activity.

* Managing interdisciplinary research consumes much time and intellectual energy on the part of the university's administration. Among the issues to be considered are distribution of funds among faculty projects, tenure, promotion, departmental pressures and salary considerations.

Characteristics of Individual Research Projects

Individual research projects typically involve one or two faculty members, plus one or two students. In some cases a post doctoral fellow or a research scientist may participate in lieu of a faculty member or graduate student. The projects are focused on a specific basic research problem which may or may not be interdisciplinary in character. Projects are generally funded for three years, at an annual budget between $40,000 and $120,000. At this level, only inexpensive pieces of research equipment may be acquired.

Decisions about which projects to fund and at what level are generally based upon a peer review of the individual proposal. Reviewers are drawn from experts in other universities as well as government labs and industrial organizations. Reviewers speak for themselves as individuals and not as representatives of their organizations. Thus there is no formal way for industry to express its research needs in selecting projects to be funded.

The findings of the research project are communicated via technical papers published in the open literature. There is often a delay of one to two years between the completion of the project and the time that the results appear in the literature. This delay plus the large number of different journals in which the results may appear make it difficult for industry to learn about new results and apply them in a timely fashion. One effective way of communicating results is via the MS - PhD students who enter industry or the universities.

Pros and Cons of Individual Research Projects

Individual, single-investigator research projects have some very important advantages:

- This mode of research support is time-tested and proven effective for university faculty members and students.
- The relative stability and duration of project funding, often for three or more years, are very compatible with MS and PhD thesis research.

*   Agency procedures are well established and relatively efficient for reviewing proposals and for monitoring grants in terms of government and faculty time.

*   Faculty at essentially all research universities can obtain support through their own individual efforts without being dependent upon a large faculty group.

On the negative side, however, individual project grants have a number of disadvantages:

*   It is difficult to get innovative high-risk research funded. The peer review process tends to be conservative and cautious about unfamilar proposals.

*   It is hard to start up new projects if the faculty member does not have a proven track record in a field.

*   The grant levels are not adequate for multidisciplinary problems which require the skills of several faculty from different fields. In most cases several faculty must combine individual research projects to achieve critical mass.

*   Individual grant levels are adequate only for acquiring relatively inexpensive items of research equipment. Because each individual is responsible for his own equipment, there is no formal mechanism for sharing equipment and ensuring full utilization.

Considerations for Balanced Funding

Let me now consider the issue of balanced funding between large centers, such as the ERC's and the proposed Science and Technology centers, versus individual research projects. In view of the many pros and cons of each funding mode, this is clearly a complex issue, and I do not have a complete answer. Perhaps a few considerations may be useful:

- **Center funding should be viewed as experimental with the potential for high payoffs.** By that I do not mean to suggest pessimism. My point is that the U.S. does not have a long record of successes with center-type funding for cross-disciplinary research involving major industrial participation. I personally am quite positive and I fully expect that the Lehigh ERC will be successful. Certainly Lehigh is backing its faith in the center with a major university investment. I caution, however, that an expectation is not a fact. I do not think we can expect all the centers to succeed for the reasons which I have mentioned elsewhere in my testimony. We do not yet have enough experimental data to predict which ones will fail or why.

- **There is a continuing need for adequate government funding of the centers.** If the center experiment is to have the best chance of succeeding, it must be adequately funded. It should be noted that funding of the first 11 centers is much lower than the 2.5 to 5 million dollars per year originally recommended by the National Academy of Engineering and announced by NSF. And the NAE recommended additional millions for student stipends, tuition, and other support. If the centers are to be successful in their research agenda, the NSF must continue to fund them on an ongoing basis. It is unlikely that industry will totally fund such centers if their focus is on long-term, basic research. The centers must be durable or the faculty members will not make the long term commitment to interdisciplinary research.

* Individual project grants are in many cases as effective as multi-investigator activities in centers. Our experience shows that individual research projects develop excellent research results. These results are significant and lead to major advances in specific areas. Centers cannot replace the well proven mode of research carried out in universities.

* Individual research projects are not funded at adequate levels of support. As the NSF has developed new programs, centers, presidential young investigators, undergraduate summer support, research initiation grants and increased funding for equipment and other activities, the individual research projects are being squeezed for funds. In addition, it is becoming more difficult to obtain multi-investigator support on individual research project funds. It is hard to accumulate data to support this conclusion, but informal discussions with our faculty and NSF program managers indicate that this situation is occurring and growing worse. The universities are ill equipped to pick up the loss in funding and have real needs to recoup their indirect costs.

Other Strategies to Leverage Private Funds

It will not be easy to achieve major increases in the level of private funds that support science and engineering research at universities. Private industry is generally reluctant to invest in long-term research performed in universities. These two types of institutions have quite different time perspectives: industry concerns itself with the bottom line as expressed in quarterly profits and annual dividends; universities concern themselves with educational programs that take years to complete and with fundamental research that takes decades to achieve payoff.

A company often seeks to gain a proprietary advantage from the results of the research which it sponsors. Universities, by contrast, tend to be quite open in communicating information, especially the results of fundamental research. It is in the nature of fundamental research that it can benefit the sponsor's competitors as readily as it benefits the sponsor.

Still I believe that government and universities can definitely do more than we currently do to attract industrial support. My experiences at Lehigh give me confidence because we have been particularly successful in developing industry support for research. Lehigh enjoys over four times the percentage of industrial support of the average U.S. research university.

We attribute our success in this area to our experience of 20+ years working with industry and our 20+ year commitment to supporting interdisciplinary research centers. The culture at Lehigh encourages faculty to work with colleagues from different disciplines and with scientists and engineers from industry. Many of our senior faculty have had careers in industry.

The research culture at Lehigh may be difficult to duplicate at other well established research universities. Nevertheless, there are some specific strategies that can be pursued by Federal agencies, the Congress, universities, and industry to leverage private funds for science and engineering research.

1) One can take more advantage of state-funded programs which are developing state objectives in R & D and are helping to renew and develop research capabilities at universities. Lehigh's Ben Franklin program in Pennsylvania has allowed us to work with industry on many projects which have given us insight into major areas which require future long-term research. In addition, the state has provided funds for facilities and equipment which have allowed our university to perform research at the cutting edge. These state programs with appropriate industrial support are a major factor in providing more funds for research. However, the specific projects which the university undertakes are often short-term problem solving. They cannot involve students who are pursuing a degree and need to work on long-term research projects. Therefore while state funds are welcome, they often cannot replace the support which federal research funds provide.

2) More private funds can be made available if proper tax strategy is developed. The present R & D tax credit and the new basic research credit will help. However, these credits expire at the end of 1988. More companies will take advantage of these tax credits if they can plan knowing that the credits will extend into the future. Extension of the credit would be most useful to our need for leveraging. In addition, the new tax law now requires students supported by NSF and other agency grants to pay taxes on their stipends. Since the students must have a base take-home pay sufficient to pay minimal expenses, the net effect of the new tax law is that we must seek more grant funds to pay basic student stipends. Repeal of such a tax will lower the cost

of student support and will make the costs of research support in universities more attractive to industry.

3) Universities could develop more private funds in support of research if less of these funds had to go to support start-up costs (equipment and facilities) of a project. Present NSF and DOE equipment programs and the past DOD instrumentation program helped to pay some of the up-front costs. Industry prefers to pay ongoing costs of research. Therefore support of equipment by other sources such as the government is a reasonable strategy to promote leveraging.

4) Industry prefers to support research which involves U.S. graduate students. This preference is due to the desire of many industries to hire the students who participate in the research. Clearly citizens are preferred. An enlarged national scholarship - fellowship program with adequate student stipends will attract the best and the brightest into graduate study in science and engineering. We see a strong interest from industry in funding research projects in which these students participate. A well designed fellowship program can be developed which could leverage industrial support, particularly in the latter years of study when students are involved in their thesis research.

Observations on Industrial Leveraging

While I am on the topic of strategies for leveraging industrial support, let me express a few related observations which may go somewhat beyond the topics raised in the Committee's invitation.

Industrial support, I believe, is one of several ways in which we can progress towards an important goal, namely that of securing effective industrial participation in the research center. A company which is helping to support the center's research is more likely to take an interest in, and benefit from the center's research and educational activities. Such a company is more likely to suggest research needs, to provide advice in planning new research, to participate in periodic project reviews, to attend the center's conferences, workshops, seminars, etc., and to contribute in many other ways to the exchange of information and personnel between that company and the center's researchers. All of these are effective in making sure that the center's activities meet the needs of industry and that effective technology transfer occurs rapidly.

I am also quite aware that in some cases, industrial support may reduce somewhat the need for government support. When it is feasible and effective to do so, it is certainly desirable to reduce the burden upon the taxpayer to support basic research. Based on our experiences to date, however, I think we may be overestimating the extent to which industry is prepared to pick up the direct costs of basic research in lieu of Federal support.

There are some indications that the pressures arising from the Federal budget deficit are causing industrial leveraging to become a goal in itself rather than merely one means to the goal of effective industrial participation. I see signs that industrial cost-sharing is being increasingly viewed as one of the main objectives of the ERC program. Industrial support is being applied as the dominant factor in formulas used to evaluate center performance and to make decisions regarding budget increases.

Let me suggest that an important issue is what level of industrial support is appropriate and should be expected. This is a complex issue because the appropriate level will vary greatly from industry to industry. The answer will depend in part upon each industry's history of supporting basic research, which may range from more than 10 percent of sales to less than a fractional percent of sales. The answer will also depend upon the composition of the industry and whether it is dominated by a few large firms or whether, as in the case of the structures-related industries which support Lehigh's ERC, there are many many firms, each of which can capture only a small fraction of the benefits of basic research. Of course, each industry's financial health and international competitiveness are also important factors.

It is significant that the National Academy of Engineering, in its 1984 report entitled, "Guidelines for Engineering Research Centers," at no time recommended that industrial co-funding of ERC's be a requirement. This was not an oversight because the NAE did examine the role of industry in the ERC's and stressed the requirement that there be effective industrial participation in the centers' research and education. The NAE saw this participation as taking different forms including not only direct funding, but also "sharing of equipment and other facilities, provision of personnel, or detailed interchanges at an intellectual level through teaching and research" (p. 9). The

NAE recognized that industrial participation is essential for the exchange of ideas and the transfer of technology but cautioned that "it is unlikely that the Centers can become self-sustaining on non-NSF funds alone" (p. 9).

The NAE's recommendations and insights are certainly very consistent with Lehigh's experiences in operating a variety of research centers, multi-investigator programs, and single-investigator projects. As I noted earlier, the private sector provides about one out of every four dollars spent for sponsored research at Lehigh. Sponsored research, however, does not necessarily mean basic resarch. As a general rule, we find that industry is willing to support those projects which are more applied rather than basic, that have a relatively short time-to-payoff, that promise to give the sponsor a competitive advantage in the plant or in the marketplace, or that offer the company preferred access to Lehigh expertise in the form of faculty and well-prepared graduates.

The kinds of academic research traditionally supported by industry can be worthwhile, but they do not match the objectives of the Engineering Research Center program as initially definined by NAE and NSF. The objectives of the ERC's are to develop new fundamental knowledge rather than to apply existing knowledge. The ERC's have a long time-frame which promises long-term breakthroughs rather than short-term incremental solutions. The research and education activities of Lehigh's ATLSS center are designed to enhance the overall competitiveness of the U.S. structures-related industries rather than the relative competitiveness of just a few firms. I believe that the other

ERC's are similarly motivated to benefit U.S. competitiveness broadly.

I do not rule out the possibility that an ERC's basic research program may eventually attract broad support from a substantial number of companies within a particular industrial segment. Rather, my message is one of caution that this possibility remains to be demonstrated; it is not yet a reality which has been confirmed.

At Lehigh, we are making a massive effort to attract a broad base of industrial support for basic research relevant to large structural systems. We are finding that this effort incurs enormous administrative, marketing, and other overhead costs as compared with traditional ways of securing research support. We would not be able to make this effort without substantial NSF support today and in the future. We think that our efforts to develop industrial support and participation will be successful providing that there is continuing, substantial NSF support. The principal beneficial result of increased industrial support will be, we believe, that it leads to more effective participation from industry. In turn, industrial participation will lead to better research being defined and performed and to more rapid transfer of research results.

Summary

Thank you for the opportunity to discuss some of the unique features of center and individual research projects. Both types of research modes are needed. I hope I have given you some insight on how to evaluate the pros and cons of each.

Acknowledgments

I wish to thank Dr. Matthew Reilly, Director of Research Program Development at Lehigh, for his help in preparing this material.

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February 25, 1987

Biographical Sketch - J. I. Goldstein

Dr. Joseph Goldstein is Vice President Research of Lehigh University. He received his BS,MS, and PhD degrees from the Massachusetts Institute of Technology in the field of Metallurgy. He joined the faculty of Lehigh University in 1968 and took over his present position in 1983. He has published over 150 technical papers and has edited or written 6 books. Dr. Goldstein is a fellow of the American Society for Metals and is a member of the Government-University-Industry Research Roundtable.

Dr. **Widnall.** Mr. Chairman and members of the Subcommittee, thank you for your invitation to appear before the Subcommittee.

Although I am a Professor or Aeronautics and Astronautics at MIT, I appear today as the President of the American Association for the Advancement of Science, an organization of some 130,000 scientists and engineers. We publish the journal, Science Magazine.

I also am coincidentally the Vice Chairman of the Advisory Committee to the Engineering Directorate, whose Chairman, Dr. Gary, you were scheduled to hear this morning. I am really quite intimately familiar with the growth of the Engineering Research Centers Program at NSF, and perhaps I'm in a position to offer some specific observations on those centers.

Your invitation raised a number of very important questions, which I will address briefly in my alloted time. I will try to summarize my testimony, which, of course, has been submitted.

You asked about the issue of balancing of the funding between the centers and the individual project grants. Let me begin by placing that question in the context of a larger issue, which really is, how best do we continue to improve the quality and productivity of our research system?

I think focusing too sharply on the either/or features of the current debate on individual grants versus centers, I think would be a mistake.

Our present research system, which, as you know, is highly regarded throughout the world, has evolved in an environment which can best be described as pluralism of both the supporters of research and the performers of research. And this fact, I think, has been recognized in your own Science Policy Task Force.

And along with pluralism, there are two other features of American science which are at the center of today's hearing, and this is the deep involvement of the universities, organized largely by disciplines into academic departments, which has been the primary focus for basic research in the United States. And many observers regard the intimate connection between research and higher education as a key element in American science.

It is thus easy to understand our deep attachment to the concept of the individual researcher, working within intellectual freedom within the university and having access to multiple avenues of support to perform this research.

We do need to remind ourselves, however, that the very pluralism which is the source of this strength has led to an evolution over the past decade of a variety of administrative, funding, and research mechanisms, and, in fact, the concept of centers has really been developed over a much longer period of time.

The current directory of research centers in the United States currently lists some 8000 entries. This concept of centers, in fact, is not a new concept and has arisen for a variety of perceived needs in the research community.

However, I think that we are in another period of change and ferment, both in our economy and in science and engineering, and this ferment is comparable somewhat to the 1960s where we saw a great growth in the research conducted at American universities.

Several trends and developments arising from this ferment are changing the support, performance, and organization of science, and I will mention just a few.

There are growing demands on our research system to help cope with what many see as our most important problem, our international economic competitiveness; the increasing complexity in resource requirements of research in many areas of science; the growing interdisciplinary research, changing the boundaries of traditional disciplines. There is a growing perception and understanding that the United States must develop, support, and encourage mechanisms for long-term commitment to university research and development, and finally there is a growing interaction and a changing character of the interaction between universities and industry in a wide range of research areas.

So in responding to your request for a discussion of some of these various research mechanisms, let me point out just two major issues. I want to speak first about the individual project research grant.

This is considered to be the main source of strength in the American science system. There is great flexibility, versatility; encouragement of independence and innovative thought are the hallmarks of this form of research. And for the National Science Foundation, historically, this mechanism has accounted for the great majority of research awards, although we see, as has been discussed, that the percentage has declined modestly in recent years, relative to the resources being put into the groups.

Another feature which has advanced in favor of the individual awards is that there is a close association of the principal investigators with their graduate students, and this gives a unique strength to American science and engineering, although it is true that continuity of support of individual graduate students remains an important issue.

And finally there is the question, which was touched on this morning, of how effective any single investigator can be in some of the increasingly complex and interrelated questions that come up in various fields of science and engineering.

As part of my remarks, I wanted to make a number of points about the characteristics of centers. First of all, I want to make the point that centers come in all shapes and sizes, and that their character is very much shaped by their mission, the environment, including the competitive environment under which they were funded, the relationships with the faculty and university departments, and the state of the associated science.

The current NSF policies are, in fact, leading to quite different centers than have been formed in the early years by some of the mission agencies. The NSF concept is an innovative experiment which rests on flexibility and wide latitude of research effort.

More directly, many of the earlier centers were focused on very well-defined needs of specific mission agencies. In contrast the NSF centers are conceived on the premise of more innovative relationships and interactive relationships between universities, industries, and the Government.

Centers do offer the opportunity to try innovative approaches. I would urge an open competitive environment for center selection.

One important feature of the NSF program is that the research topics were, in fact, not defined in advance, but each university was left up to conceive its program with its own understanding of the needs of a particular industry group and the strengths of its own faculty, and these proposals were then submitted, and there was a very open competition for which group would really put together the most exciting and dynamic program, and I would certainly urge that to continue. The centers do offer the opportunity to try these innovative approaches.

It's very important that these centers—and I think the NSF centers do—have a very strong commitment to education. One of the real fallout benefits from these centers will, in fact, be the training of a generation of graduate students.

We were early talking about information transfer from the exciting programs that are going on in universities into industries. One of the most effective forms of that transfer is, in fact, the people. The people have been educated in interdisciplinary centers, and the industries into which they will go. I think that's a very important form of information transfer.

Also the NSF centers have the opportunity to develop curriculum in some of these new interdisciplinary areas, and that's an extremely important feature.

And one important consideration is that the health or success of any of these centers depends on its ability to be innovative, and this depends on the underlying health and strength of the universities.

This translates into specifics. You have to have good faculties, strong departments, and an adequate system of support of equipment and facilities, as well as a strong base of individually performed and supported research.

I think that increasing the ties between industries and universities can only be helpful, whatever research mechanisms are used. However, I would caution that there are some concerns about the industry/university research interaction. They do not automatically succeed. The level of industrial involvement in the universities is on the order of 5 to 10 percent. We are not likely to see major changes in that level. They work better in some fields of science and engineering than they do in others and I think that is likely to continue.

Industry/university research centers should not be considered a panacea for a whole variety of problems. They will work better in some industries than they will in others.

The relationship between the level of support for centers and individual projects will always be a function of the field of science or engineering, as will the level of appropriate university/industry interaction.

Proposals for centers are often difficult to evaluate. You need to give greater attention to the problems associated with the process. Some traditional peer review mechanisms are not as useful as they are for individual awards and yet it is important not to rely solely on the issues of management and political considerations.

In concluding, let me restate my views in the form of five points. I do support the NSF initiative in establishing centers and supporting departmental team and group awards. I consider the balance among the overall components of NSF resource allocations so far, as being proper. I do not see cause for alarm. While the percentage of the overall budget for individual investigators has dropped, the overall budget increases have generally led to absolute increases in available resources. At the same time, however, I wish to reaffirm my own belief and commitment to the need for a strongly supported individual-investigator program.

This research constitutes the basic building blocks of a strong, healthy, productive science and engineering system. I think I would begin to express concern and alarm if major realignments in future resources resulted in more than modest relative declines in individual project support in an overall sense and in specific fields.

In any event, I would urge continuing to support the growth of individual project research at levels at least commensurate with inflation. A healthy base is necessary for individuals who are not involved in the centers and it is really essential when center funding in a given area begins to terminate. We simply must have a healthy individual base for some of those individuals to go back and continue their research activities.

One concern regarding centers and individual projects is that individual groups are the best way—one last consideration is a concern that we want to avoid concentrating all the investigators who wish to work in a particular area and to a single geographical location. It is very important to maintain a healthy base of individual project research even in those areas that we consider to be these frontier areas that require interdisciplinary support, so that you will have sort of a broad base of research in some of these frontier areas and everybody doesn't have to congregate in a single geographical area in order to participate in an important way in this sort of research.

In closing, let me say that the questions of balance you raised are vital but they do not have simple answers, as you have previously recognized. It is pluralism in all kinds, in the funding of performers and research mechanisms that we will find the source of our vitality and success in American science and engineering.

Thank you, Mr. Chairman and members of the Subcommittee, for the opportunity to appear today.

[The prepared statement of Dr. Sheila E. Widnall follows:]

Statement by

Dr. Sheila E. Widnall

President

American Association for the Advancement of Science

on

The Fiscal Year 1988 National Science Foundation

Budget Authorization Request

Submitted to

Subcommittee on Science, Research and Technology

Committee on Science, Space and Technology

U.S. House of Representatives

February 25, 1987

Mr. Chairman and Members of the Subcommittee:

Thank you for your invitation. Although I am a Professor of Aeronautics and Astronautics at MIT, I appear today as the President of the American Association for the Advancement of Science -- an organization of 130,000 scientists and engineers. We publish the journal Science.

Mr. Chairman, your invitation letter raised a number of very important questions which I will address briefly in my allotted time. You asked that we discuss the issue of balancing funding between centers and principal investigators -- in the context of "pros and cons" for each and "what strategies other than centers could be employed to leverage private funds for science and engineering research." Finally, you expressed interest in learning what principles could be applied to evaluate the balance between centers and individual funding.

The Central Issue: Research System Quality and Productivity

Let me begin by suggesting that your questions might well be placed in the context of a larger issue: how best do we continue to improve the quality and productivity of our research system? Focusing too sharply on the "either-or" features of the current debate on individual grants vis-a-vis centers would be, I think, a mistake. Even the idea of an "appropriate mix" needs to be set in the broader context.

Our Present Research System: Its Evolution

Our present research system -- highly regarded throughout the world -- has evolved during the past half century in an environment that can best be described as pluralism -- of supporters and performers. Your own Science Policy Task Force study of the past two years makes this case strongly in explaining the vitality of American science and the spectacular American success in Nobel Science Prizes.

Along with pluralism there are two other features of American science which are at the center of today's hearing topic: (1) since the late 19th century, the university, organized largely by discipline into academic departments, has been a primary locus for basic research in the United States; and (2) many observers regard the intimate connection between research and higher education as a key element in the success of American science.

Thus it is easy to understand our deep attachment to the concept of the individual researcher working within the intellectual freedom of the university and having access to multiple avenues of support to perform research. We need, however, to remind ourselves that the very pluralism which is the source of our strength also has led to the evolution over the past decades of a number of administrative, funding and research mechanisms. Ours is a very dynamic research system indeed, rich in variety. In looking back over the years it is possible to identify the growth of new and different ways of supporting and performing research: research centers, research institutes, "seed" and "catalytic" programs, research teams, organized research units, interdisciplinary groups -- and various combinations of all of these.

Why Have Changes Taken Place?

Why did these different mechanisms arise? The short, simple answer is that times and conditions changed; new challenges, opportunities and problems appeared. The needs and policies of government changed over time and, perhaps even more important, science changed, often dramatically.

In science and engineering we are immersed in a virtual explosion of new knowledge and new fields -- worldwide. This explosion is taking place everywhere: from the far reaches of astrophysics to the innermost world of molecular biology, from the frontiers of new computer concepts and biotechnology to everyday commingling of science and engineering in helping solve society's problems.

Another dimension of change arises from time to time as government reacts to political or national security crises. For example, the great build-up in university research capabilities during the 1960s was a direct result of government policy in response to perceived threats to our national security and prestige. In universities all over the country, major program buildups took place which were funded by the federal government.

Research centers and organized research units began to expand in this environment. One study showed that by the late 1970s over 5,000 organized research units (ORUs) had been established within the 3,000 or so colleges and universities in the United States. The 1986 edition of Research Centers Directory contains 8,354 entries.

These ORUs and centers vary from single-person "paper" organizations to very large institutions such as the Jet Propulsion Laboratory which is larger than its nominal parent, Caltech. They arose from a variety of circumstances: (1) the enlistment of universities in the service of a particular government purpose (NASA, Defense Department, Interior, Agriculture); (2) the willingness and eagerness of universities to cooperate with the government in serving these purposes; (3) the initiative of universities in seeking alternative ways to perform research and provide positions to many who could not be given academic appointments otherwise; and (4) the entrepreneurial drive of faculty members to serve their own purposes as well as those of the university, government and industry. (At my own university, the MIT Instrumentation Laboratory grew out of Professor Charles Stark Draper's initiatives.)

Trends for Future Change in Our Research System

I think we are now in another period of change and ferment -- both in our economy and in science and engineering -- comparable to the 1960s. Several trends and developments arising from this ferment are changing the support, performance and organization of science. I'll cite just a few:

- The growing demands on our research system to help cope with what many see as our most important problem: our international economic competitiveness. I note that nearly two hundred Senators and Representatives joined the new Congressional Competitiveness caucus within days of its formation!
- The increasing complexity and resource requirements of research in many areas of science. I don't need to convince you of this because you've been examining the entire research facilities and instrumentation domain for some time and have supported the much-needed instrumentation buildup by NSF -- as shown in Figure 1.
- The growing interdisciplinarity of research; changing boundaries of traditional disciplines; and the emergence of new "hybrid" disciplines. Report after report issued by the National Academy of Sciences underscores dramatic and revolutionary changes in the structure and relationships within science, which I noted above.
- A growing perception and understanding that the United States must develop, support and encourage mechanisms for long-term commitment to research and development in U.S. industry. For example, a recent "State of The Art Review of Advanced Electronic Materials in the United States and Japan" issued by the National Academy of Sciences made this point clearly.

- Closely related to the previous point are the growing interactions between universities and industry in a wide range of research areas. It is, of course, not new that industry and universities have common interests; in many fields of science and engineering it is literally true that industrial research and academic research grew up together. What is new is the major national emphasis on these interactions and the return to a facilitating role by government.

The Questions of Balance

I think it is clear by now where I am heading with my line of argument. The composition and structure of our national research program generally and that of the National Science Foundation specifically have been and will continue to be shaped by a broad array of forces and influences: some arising from government, some from science itself, and some from the international environment. The various "balances" or "mixes" related to resources for various fields of science and engineering, different funding mechanisms, different priorities (e.g. defense/non-defense) will result from a complicated interplay of all these forces.

In short, in reply to your question about balance between centers and individual investigators I regret that I have no simple answer. It is a very complex issue which depends on a lot of things, as noted above. However, I'll return to this point a little later, in my concluding comments.

Now, to respond to your request for assistance in searching more deeply into this area, I'll suggest in brief form what seem to be some of the principal features of several of the different funding mechanisms. My comments are representative, not exhaustive:

Individual Investigator Projects: This approach, as noted above, is considered to be one of the main sources of strength in the American science system. Great flexibility, versatility, encouragement of independence and innovative thought are seen as the hallmarks. And, for the National Science Foundation, historically this mechanism has accounted for the great majority of resources and awards -- although, as Figure 2 shows, the percentage share has declined modestly in recent years relative to group resources (which includes centers and multi-investigator awards of various types.)

Another feature often advanced in favor of individual awards is that the close association of principal investigators and students -- particularly graduate students -- gives a unique strength to American science and engineering. On the negative side, however, it has been noted that graduate students have somewhat uncertain prospects in their dependence on working with a particular investigator, as funding cycles and other factors change and the investigator may lose support.

Finally, there is the matter of how effective any single investigator can be in working on a number of the increasingly complex, interrelated questions in various fields of science and engineering which cross traditional boundaries.

Research Center (or Research Institute) Awards: A central argument used by the National Science Foundation and others in establishing and supporting centers of various kinds is their ability to provide an interdisciplinary or multidisciplinary approach in advancing research at various cutting edges of knowledge. It is suggested that they provide a more effective organizational framework for carrying out coordinated effort at the departmental, university, regional, or even international levels. Further, centers often are the only way to attack particularly complex problems or topics.

One feature of centers considered positive by many is that they permit the rapid marshaling of resources and researchers when a strong, urgent need has been articulated. A case in point is the establishment of the NSF Engineering Research Centers Program: a 1983 study performed for OSTP by the Academy's Committee on Science, Engineering and Public Policy (COSEPUP) -- "Research Agenda for Increasing the Use of Computers in Design and Manufacturing" -- helped lead directly and quickly to launching the Engineering Research Center program.

There was widespread support for the need to act swiftly -- in the engineering community, in the Executive Branch, and in the Congress. It is highly unlikely that a major program could have been mounted quite this way -- and received the necessary political support -- if it had been done in a comparably-sized program based on individual grants.

This very ability to act swiftly and decisively is associated with one major criticism of the center approach to supporting research: it carries with it the potential for a much stronger "managerial" or "administratively set direction" tone than is characteristic of the individual project mode. In short, if carried too far, it is suggested that the pluralistic base of American science could be narrowed -- perhaps to the detriment of our scientific progress and capability.

Team or Group Awards: Intermediate between centers and individual investigators are the use of small research teams or groups. Less formally organized than a center, such groups may resemble a confederation of associates who work on interdisciplinary topics at various levels. Key characteristics are coordinated research, shared data, and common data, and common instrumentation and equipment. My impression is that such group or team approaches are on the rise, although we do not have good statistical data on this.

Lack of Adequate Data

Indeed, this latter point provides me with the opportunity to focus on what is a major difficulty facing you and us in the scientific and engineering communities: we simply do not have good data bases and solid empirical studies related to the questions you have raised for this hearing. There have been some limited evaluations of individual vis-a-vis centers in the industry-university cooperative research center area but data such as this is relatively scarce.

Within the past year both the General Accounting Office and the National Academy of Sciences have made contributions: (1) the GAO in its two studies for your Committee and, (2) the National Academy of Sciences in holding a conference dealing in part with questions similar to yours about a year ago.

To summarize their findings briefly:

- The GAO found that the particular funding mechanism for university research played a lesser role in helping universities improve program quality than their ability to obtain grant funds from such sources as the federal government, state government, industry, and the university itself. Further, important dimensions of research effort were less affected by particular funding mechanisms than by the field of science.

- In the Academy meeting, it was stressed that the nature of research has been changing. Difficult, real-life scientific and engineering problems require multidisciplinary approaches. (The NSF

> Engineering Research Centers are a response to this need.) Universities are not well structured to organize such research groups. Conference participants identified the need for universities to consider new institutional arrangements that would permit easier multidisciplinary research.
>
> There was general agreement that the correct mix of cross-discipline, multi-investigator grants on the one hand and single-discipline, single-investigator grants on the other hand on the other hand will vary by discipline. The appropriate mix will be influenced by social need, research opportunities, and the requirement for specialized and expensive specialized and expensive instrumentation and facilities.

In all, while the GAO and the Academy each have made a good contribution, much more serious study and examination must be done. All of us could benefit from such work. You may wish to raise this matter with the NSF when its witnesses appear before you next month.

Comments for Your Consideration

You asked in your letter of invitation for some advice to assist you in your deliberations. The following comments and observations are presented in that light. The order of their appearance has no particular connection to their relative importance. (1) Centers come in all shapes and sizes. Their characters are shaped by their missions, their environments -- including the competitive situation, their relationships with the faculty and university departments, and the state of their associated sciences.

(2) Building on point (1), current NSF policies are leading to centers quite different from many of the centers established and supported by federal agencies in earlier years. In contrast to the specific mission orientation of various earlier centers, the NSF concept is an innovative experiment which rests on flexibility and wide latitude of research effort.

More directly, many of the earlier centers were and are focused on the specific needs of government -- and I don't disagree with this orientation for many such centers. In contrast, the NSF centers are conceived on the premise of more interactive relationships among universities, industry and government. It is suggested that the potential for supporting "off-beat," innovative work will be higher in this kind of environment. At the least, the degree to which this feature is present ought to be a part of future examination.

(3) I hope that pressures for accountability will not lead to overly rigid rules in establishing and operating new centers. Also, drawing upon the sources of what has made American science successful, I would urge an open, competitive environment for center selection. This feature should be coupled with considerable flexibility on the part of the centers to define their own specific research programs under certain general guidelines. In no way do I suggest total carte blanche.

(4) Centers do offer the opportunity to try innovative approaches. Indeed, the use of centers in various areas may itself be an experiment worth supporting. Center programs should be designed to permit extensive innovative collaboration among a variety of partners on the part of universities. The greatest potential is more likely to be achieved when universities are able to explore opportunities as they see them.

(5) In general, centers -- those previously established and those yet to be -- must have a strong commitment to education. If they are to serve the needs of the universities as well as the needs of the nation, they should not be "foreign bodies" implanted on the campus. I realize that the potential for this will vary among centers; clearly, this feature is less

likely to be present in short-term, mission-oriented centers than in those having a long-term, more general character.

(6) Centers of all kinds should be evaluated by their ability to attract broad faculty participation -- and not by their attractiveness to temporary research staff.

(7) An important consideration is that the health or success of any center or center program depends on the underlying health and strength of the associated universities. This translates into a range of specifics: good faculty, strong departments, an adequate support system of equipment and facilities, and a strong base of individually-performed and supported research.

(8) A managerial consideration for centers is that they not become overly complex administratively. This means striving to make sure the "intellectual overhead" of coordinating, reporting and directing research effort doesn't get out of hand.

(9) Centers ought to have a certain fluidity. Individual researchers should be able to move in and out of them, to and from other programs within the university.

(10) We should look to the nature of the commitment by the university to the center. Some key questions which should be asked of universities include what resources are they willing to allocate in the form of faculty, funds and facilities for the long pull?

(11) A lesson to be drawn from the 1960s and 1970s is that really successful centers have had long-term support by the federal government. I would raise a cautionary comment about establishing automatic five-year

support cutoff rules. Reality and experience suggest a greater degree of flexibility in making judgments of this sort -- even if fixed rules are easier to administer.

(12) All parties to plans for embarking upon centers should carefully consider strategies for continuation when "core support" declines or vanishes. Here, I would argue that the importance and utility of centers will depend, to a significant degree, on the continuing capability of investigators to acquire support -- either as individuals or as members of teams or groups under the "center umbrella."

(13) Increasing the ties between industry and universities can only be helpful, whatever research mechanism is used. There clearly are positive attributes to using a mix of centers, groups and individuals. Yet, there seems to be a distinct trend which involves greater use of centers and groups in industry-university interactions. An important feature of this trend worthy of closer examination is the extent to which new connections and people --in both industry and the universities -- are developing.

(14) However, I must offer a word of caution on industry-university research interactions. Important as they are, they are also fraught with difficulties and do not automatically succeed. Moreover, the level of industrial involvement -- of all kinds -- in academic research is on the order of five percent of the total of research effort done in universities. And this fraction is not likely to grow substantially; thus industry will never, I think, take on a major role in supporting academic research -- although this varies considerably by field of science and engineering.

Some have seen industry support as one means to reduce the federal government's role in supporting basic research, but I think they are mistaken.

(15) A final note of caution on the university-industry connection is partly related to the previous point. Industry-university research centers should not be considered as a panacea for a range of problems -- from national economic competitiveness to what's wrong with an ailing domestic industry. The centers will work in some industries and with some firms but not in others. Finally, the basis for successful cooperation has often taken a long time to build even in areas where success has been achieved.

(16) The relationship between levels of support for centers (and groups) and individual project awards always will be a function of the field of science or engineering. In some fields, such as the atmospheric and ocean sciences and the geosciences, centers have played and will continue to play very major role. In others, the "mix" will be quite different. The level of analysis must take place below the overall aggregative data as shown in Figure 2.

(17) Proposals for centers are very difficult to evaluate. We need to give greater attention to the problems associated with this process. Traditional peer review processes are not as useful as for individual awards. Yet, it is important to avoid major reliance on "management" and "political" considerations. Although this is a major topic in itself, I would like to present a concern of the AAAS about what seems to an increasing trend for research grants, research facilities, and centers to

be allocated on the basis of political clout. In any event, the criteria issue for centers is far from being sorted out in a satisfactory manner. It remains as a very tough challenge for all of us.

Conclusions

In concluding my statement today, let me restate my views in the form of five brief points:

1. I do support the NSF initiatives in establishing centers and supporting departmental (or "mini-centers"), team and group awards. NSF director Erich Bloch and the National Science Board are moving in the right direction -- subject to a number of the caveats outlined in my testimony.

2. As I consider the balance among the overall components of NSF resource allocations so far during the 1980s, I do not see cause for alarm about the data as reflected in Figure 2. While the percentage allocation for individual investigators has dropped, the overall budget increases have led generally to absolute increases in available resources.

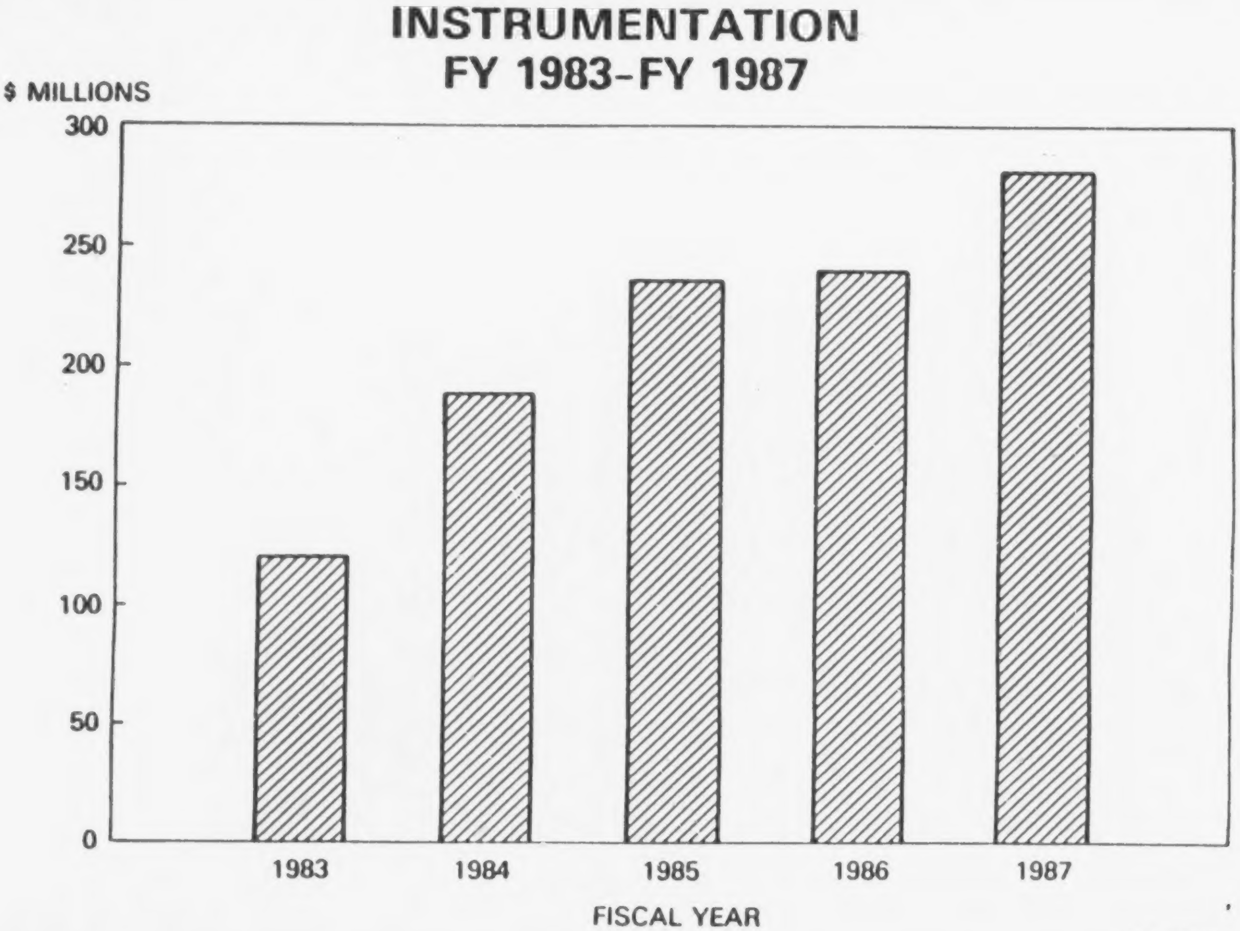
3. At the same time, however, I wish to reaffirm my own belief and belief and commitment to the need for a strongly supported individual investigator program. This research constitutes the basic building blocks of a strong, healthy, productive science and engineering system. I think I would begin to express concern and alarm if major realignments in future resources resulted in more than modest relative declines in individual project support -- in an overall sense and in specific fields. In any event, I would urge continuing to support growth of individual project research at levels at least commensurate with inflation.

4. One last consideration regarding centers and individual project awards is that individual grants are the best way to assure widely dispersed investigators of the potential for continuing to work. And while I support the use of centers we must be careful about getting to a state of resource allocation and funding mechanisms in which too many investigators would be faced with the choice of congregating in centers or not participating in research of any consequence.

5. In closing, I'll return to where I began. The questions of balance you raised are vital but they are not likely to have simple answers, as you have recognized in your Science Policy Task Force studies. It is in pluralism of all kinds -- funding, performers, and research mechanisms -- that we find the sources of vitality and success in American science.

Thank you, Mr. Chairman and Members of the Subcommittee -- for the opportunity to appear today and for your support of science and engineering over the years.

FIGURE 1

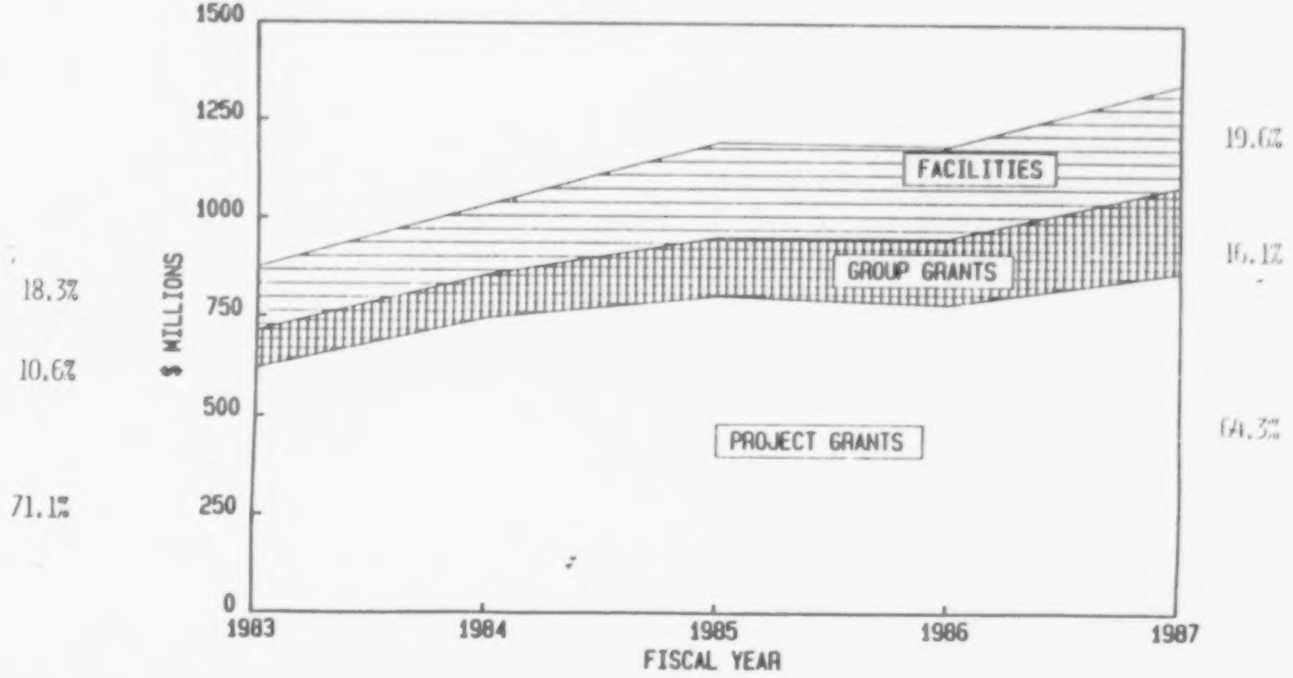


O/D 86-142

FIGURE 2

NATIONAL SCIENCE FOUNDATION
PROJECT BALANCE

FY 1983 - FY 1987



* INCLUDES MPS, AAEO, BBS, ENG, & ASC ONLY

Biographical Information

Sheila E. Widnall

Sheila E. Widnall (aeronautics, astronautics), 1938; B.S., 1960, M.S., 1961, and Sc.D., 1964, Massachusetts Institute of Technology. With MIT since 1964; professor of aeronautics and astronautics since 1974. Director of university research, U.S. Department of Transportation, 1974-75. Lawrence Sperry Award, American Institute of Aeronautics and Astronautics, 1972; Outstanding Achievement Award, Society of Women Engineers, 1975; member, National Academy of Engineering; Board of Directors, AIAA, 1975-77; Board of Visitors, U.S. Air Force Academy, 1978-84; Executive committee, Division of Fluid Dynamics, American Physical Society, 1979-82; Committee on the Education and Utilization of Engineers, National Research Council, 1981-84. Current Activities: Boards of Directors, Carnegie Corporation and Chemical Fabrics, Inc. (vice Chairman); Panel on Public Affairs, APS; U.S. National Committee on Pure and Applied Mechanics; Committee on Fluid Dynamics, American Society of Mechanical Engineers; Advisory Committee to the Engineering Directorate, National Science Foundation; associate editor, Physics of Fluids, ASME Journal of Applied Mechanics. AAAS activities: Board of Directors and Council, 1982-86; Executive Committee of the Board, 1984-; Committee of Judges, AAAS-Westinghouse Television Award, 1983-; member-at-large of the Section Committee, Section on Engineering, 1984-88. Current President of AAAS.

Mr. MacKay. Those are three excellent presentations. Let me frame a question in my own. We are experimenting also in interdisciplinary approaches, the Congress. Our whole process is interdisciplinary.

Let me sift what you said through my matrix. These centers are in many ways entirely new. We have had centers but in many cases they have been agency sponsored mission driven centers. Now, we are talking about interdisciplinary approaches to basic science, the idea being that many of the new breakthroughs are coming at the interface between the narrow disciplines.

The question is how do you evaluate whether this center approach is succeeding or not? It seems to me that you have said one, we need to be sure that the basic idea of continuing to provide education is not lost in the effort to try to be sure we are getting greater output. Two, you are saying don't judge it unduly by whether private industry is putting money in it, because in some cases, private industry won't be able and in other cases, the money aspect just isn't that significant.

What kind of mechanism should we set in place? You have said, Dr. Widnall, that peer review will have to be different. I agree. We were already in the process of finding peer review taken over by old fashioned lobbying.

When you move from individual researchers to centers, you get a pork barrel dimension that we didn't have. I wonder whether peer review is going to be possible and if so, should we have a mechanism that reviews not only the ones that NSF sets up but the ones we set up. We have set up some fairly bizarre centers. We set them up in the budget of the U.S. Corp of Engineers. We set them up in all kinds of budgets.

Should there not be an overall effort to review all of these, maybe just to try to—is the need to keep the system honest going to be a greater need when we start putting bricks and mortar in and instrumentation and we start grooming the centers over individual research.

I would like to hear your response to that. I think to the extent there is going to be any program evaluation of this change, it is going to be done by this Subcommittee.

Dr. Widnall. Let me make a few remarks on evaluation. I think the first thing I would say is first of all, the NSF program is in fact very new. I suppose one of the evaluations I was talking about was just the basic decision on which proposal to select. I think that decision is in fact fraught with difficulty. One needs a panel that can in fact evaluate the quality of what is being proposed as well as a group of people who can understand the interactions between the various fields, the soundness of the management approach, and the likelihood that the entire enterprise will be successful.

I think right at the outset, there is an issue of evaluation of the center proposals. I am sure you know that in the initial solicitation, the NSF received on the order of 200 proposals for what turned out to be five awards. Clearly, there was some sort of major issue there of sorting through all of that.

I do believe very strongly that the best proposals are going to be received in a situation where you let the individual universities, who have in fact very good ties with specific industries and a real knowledge of the research that is going on, if you let them make the connections, design the research according to their own faculty strengths and simply let them put forward the soundest proposal they can put forward and then you have this competition to decide on the basis of those proposals who is really the best.

I think NSF itself will have a major issue in evaluating the outcome of these centers at the end of the three years. There were major goals set in terms of the soundness of the research, the research accomplishments, the interaction with industry, the number of graduate students trained, and the curriculum development and how long this center is able to maintain an important presence within the university environment.

I think those are the dimensions of the evaluation that the NSF will need to look at. As these centers, I will use the word "phase down," I think that itself is going to be a difficult problem. For those centers that have been successful at putting together a very cohesive university/industry team, with the help of a good strong base of individual research, they will likely be able to continue the momentum that they started.

Mr. MacKay. Would you see, since this really becomes more of a joint venture with the private sector and with perhaps the professions, would you see a new dimension to AAAS or one or the other of the national academies, where they might perhaps assist in the peer review?

Dr. Widnall. Well I think there is in fact a certain amount of that going on. You mentioned the professional societies. You mentioned AAAS. You mentioned the National Academy. In fact, these organizations are all composed of people and it is not surprising that it is in fact the same people, whether the National Academy—in fact, I believe the National Academy of Engineers has in fact put several panels in place to help NSF in the evaluation process. Members of that same group in fact serve on the Engineering Advisory Committee to NSF to put the input in at an earlier position. Members of the engineering profession and members of AAAS serve in a whole variety of roles in evaluating that.

I think the scientific and engineering community has really linkages that allow it to help the nation, NSF in particular, to perform these evaluations in a variety of ways.

Dr. Goldstein. I think one thing we should keep in mind is this is an experiment. The real value of these centers will not be apparent, I think, for 5 to 10 years. It is clear that getting interdisciplinary teams together, at least our experience at our university is, it takes time. The up front effort of finding the space, putting in the experimental equipment and the like takes time. Working with industry takes time. We have spent an inordinate amount of time going out and working and talking with the industry to explain what it is that we are doing. We have had some excellent help through the Government and through industry forums. This all takes time to put it together.

Making an evaluation early on, I think, is going to be a mistake. Three years to five years out is the time when we need to make the go/no go kind of evaluation. In the meantime, NSF represents good science and good engineering. We need to have the review of that from the outset. I think it is very important that we go through the peer review process as we traditionally do with projects, to make sure that the science and engineering that is coming out is first rate, high quality.

We need to look at the technology transfer, industry participation level at some stage in this. That is extremely important. Is the industry getting something from the centers after three years? Is there a flow of information from the center to industry and is industry helping the center set its research agenda, at least to help it in being sure that we are tackling the right kinds of problems that will in the long run be important to the industry.

I think there must be panels from industry put together in each of the technology areas to take a look at the centers and to help NSF in the evaluation.

As long as we remember that continuous funding is important over the initial periods, that we must keep these centers running so that we can evaluate the experiment, that is the first step.

Mr. MacKay. Dr. Shapiro.

Dr. Shapiro. Peer review has been an important component of the success of U.S. science over a long period of time. I think I agree with what I sensed to be your own point of view, that it is even more important in this case than it has been previously, because as we all know, organizations have a greater capacity to sustain support beyond their useful lifetimes than single individuals. I think it is extremely important and I think it is very doable.

These centers will be successful and I support them now because they in fact are supportive of recent developments in science. There are plenty of scientists and engineers out there in industry and other places who can help us in the peer review process.

I think it is extremely important for all centers that peer review be a part, an important part of ongoing evaluation. There is no reason why we can't evaluate these. We will make some mistakes as we go along. No more mistakes than we are typically used to and the system can tolerate some. I think it is an extremely important part of the future of this effort.

Mr. MacKay. Thank you. Mr. Boehlert.

Mr. Boehlert. I am smiling when you tell that story, because I played the typical pork barrel project politician last year, and I was so happy to call Dr. Frank Rhodes at Cornell and tell him I got $10 million in the CR (Continuing Resolution), and he advised me they weren't going to accept it, because it wasn't through the peer review process. So he's educated me, and I really commend him. And that was a valuable lesson for me, and it should be for all of us.

And then the people said, well, don't worry, Cornell can do that, they can be so magnanimous because in the peer review process they are going to get it all, anyway. Well, they didn't. And I commend Dr. Rhodes for what he did, and I support what you're saying in support of what our Chairman is saying.

Let me ask all three of you my standard question of the day, because it's a toughy for us, as we look ahead. I mean, sure, you're going to have colleagues up here say the way to fund the SSC is take money out of some weapons system for the Defense Department, but realistically that's not going to happen, probably. So we are going to have to make some hard choices.

I like what the Administration is doing, doubling the NSF budget over the next five years. I have some genuine questions about its ability to manage that additional money, given its present configuration, but I'll ask that in a moment.

But just in the Superconducting Super Collider, what do you think overall?

Secondly, as we have to establish priorities, how would you advise me to prioritize that? Just give me some reaction.

And Dr. Shapiro, I must confess that your answer won't mean as much as the other two, because Michigan handed Syracuse the first defeat of the season on the basketball court. [Laughter.]

Dr. **Shapiro**. Well—excuse me. I think I would associate myself with what I took to be the position of President Gray of MIT just a few moments ago; namely, if we accept as given that the resource base of science in this country is not going to be expanded, then I would reluctantly have to come to the opinion that the super collider ought to be deferred until such a time as we as a nation believe we can expand our overall level of commitment to science.

I think if we have to make a decision within the current level of resources that we have now, I would somewhat sadly come to the conclusion that I would recommend deferring it. I'd put it second on the list to the existing areas of support in NSF and elsewhere, the individual-investigator grants, the research centers that we are developing, and so on. I think that would be a sad day for this country, because I think we are wealthy enough to afford it, and we ought to be making larger investments in our future, and fewer concerns about current consumption, but that's a whole different problem that you didn't ask about. But I think it's related to those kinds of issues. And to the extent that we believe in our future, we will have to come to those kinds of decisions.

But if you force me back to saying, well, how do we deal with the pie that we actually have, I'd have to—I would recommend deferring it.

Mr. **Boehlert**. May I say something particularly to you that I have said to Frank Rhodes, among others? The typical university president will grab a MacKay from Florida or a Boehlert from New York and tell us that the existing pie is not big enough, we can't cut it up into ever smaller pieces and distribute it around. What we have got to do is enlarge the pie. Guess what? I agree. So does he. You've got to do a better job lobbying, and you've got, I would say—you know, your trustees, you've got to get the people that you are in communication with all the time, to convince our colleagues as a practical matter when—and I wish you had time to do it—when the NSF budget comes on the floor, go sit in the gallery and you will see MacKay and Boehlert and a few of us on this Committee talking about how important it is for America's future and everything else, and everybody else will be yawning or off doing something else. And this is extremely important.

So please help us with that lobbying effort.

Dr. **Shapiro**. I couldn't agree more. I will try my best.

Mr. **Boehlert**. Thank you so much, Doctor.

Dr. **Goldstein**. I share the same opinion with Dr. Shapiro. I think the one thing that we ought to consider, that was discussed, I think, in the previous group, is that there are a—that we should be thinking about cooperation with other countries. This is such a large project that that kind of science goes across national borders in such a way—we're not talking about competitiveness, we're not talking about the issues that we're worrying about in some of these Engineering Research Centers. And it seems to me that cooperation with other countries in the planning of this, the execution, the use of the facility and the like, will not only be better for science, but it will also be better for our budget.

Mr. **Boehlert**. Do you get the impression, as I do, that DOE is not too anxious for an international cooperative venture, that they want a—that they've got sort of a "go it alone"?

Dr. **Goldstein**. I don't believe so.

Mr. **Boehlert**. Okay. Thank you.

Dr. Widnall.

Dr. **Widnall**. Well, I would put the greatest emphasis on the proposed increases in the NSF budget. I think one of the healthy trends we have seen in this nation is a—I would say spreading of the research environment into every state. Many universities are major players in the game that were not, say 20 years ago. I think it's very important to feed that base. It's important for those communities and states.

I think that calls for, in fact, major increases in NSF's budget, with attention to first rate quality across all the areas that NSF supports.

I think the Superconducting Super Collider is one of those projects that have driven us forward, no question about that. We have constantly driven ourselves, we have driven ourselves in this high energy physics area, we have driven ourselves in space, we have forced ourselves to do things that were sort of major, major things that allow us to really sharpen our ability, sharpen our technology, sharpen our science.

But I would not want to see that come at the expense of the base, what I consider to be the base of American science and engineering, training of graduate students, the constant pushing back of the frontier by individuals and groups. I think that's too high a price to pay. Obviously I would like to see us be able to do both, but as you say, that's a major debate that's going to have to take place.

Mr. **Boehlert**. The other question is this. The centers—it's a five-year commitment on the part of the government. We tend as Americans to want instant results. You know, measure after the first 30 days of operation, tell us your success story. And we can't do that. Three to five years, you say, is a minimum.

Is it realistic to assume at the end of five years we say to the centers, okay, you go your way now, we're looking elsewhere to devote our resources? Is it likely to go a 10-year cycle? Is that more realistic?

Dr. **Widnall**. Well, I do believe it will vary from—in different fields of science. I think in perhaps some of the more applied fields that what the university has initial—initially proposed was perhaps some opportunity they saw to sort of bring things together, that things in various fields were in a certain point, they could bring things together, make a big impact.

It is in fact likely the case in some areas that in fact at the end of five years you have either done it or you haven't done it.

On the other hand, we assume that the quality of those individuals is very high, that they will want to maintain their research program, perhaps not specifically focused on the topic that the center was originally formed to concentrate on.

Now you have one or two choices at that point. You can either make sure that the base of individual project research in the country is sufficiently strong so that people can transition back to what they were doing originally; you can use the center as an umbrella for collecting together a number of grants for small and large group grants in areas related to the original mission; or you can keep in some very generally defined centers, you can keep that center going in a variety of ways.

I think NSF could perhaps transition to sort of step funding, the way NASA had originally done. There are a variety of mechanisms. I don't really believe that a center should be given a blank check for 10 years. I think that that would not be a healthy thing to do.

Mr. Boehlert. Case by case, then?

Dr. Widnall. Case by case, field by field.

Mr. Boehlert. Thank you.

Dr. Goldstein. In my written testimony I predicted that some of the Engineering Research Centers will fail. This is an experiment, and so some of them will not work out as well. It could be for many reasons. It could be the leadership. It could be that the field—that the original rationale for the center and so on may not be exactly right, and the like. Though I'm thinking——

Mr. Boehlert. Excuse me. May I pause right here. Wouldn't our program be a massive failure overall if some didn't fail?

Dr. Goldstein. That's right.

Mr. Boehlert. I mean we've got to reach way out there.

Dr. Goldstein. We are doing many things that we've got certain kinds of experiments, certain types of science and engineering that we are doing that we wouldn't do if we didn't have these Engineering Research Centers. And so some of them are experiment and some will fail. That's not all bad, and I think——

Mr. Boehlert. I'm not sure we could define failure. I mean we could probably debate the rest of the afternoon on what is failing.

Mr. MacKay. That's the—that's the problem; need for program evaluation is going to become very intense when it comes time for NSF to say you failed, and they then go and their lobbyists then go to the Congress and say that's not right, we didn't fail. And furthermore, if you'll just give us some more money, we'll prove we didn't fail.

I wonder if we are ever going to—unless we kill all of them every five years, if we're ever going to kill any of them.

Dr. Goldstein. Well, the National Academy's original study, which set these up, said it must make an impact on international competitiveness. It must be interdisciplinary projects. It must involve industry. I maintain that some of them will not do that, and we'll know about that.

Mr. MacKay. By that standard. I didn't mean to——

Mr. Boehlert. No, no, that's fine.

Dr. Shapiro, do you have a comment?

Dr. SHAPIRO. Yes, I think I do. I think I would favor in many cases really time-limited grants. I think from the very first, people have to understand there's not a check here forever and start planning for that day.

Now it's true that we won't know for three to five years, as has already been indicated, just how successful they have been. But it seems to me that we are better off erring on setting up a pattern of beginning, allowing a set of years in which funding is predictable and steady, but then a set of years which you are dead certain funding is either going to disappear or gradually decline. I'd prefer to err on that side, because it is so hard to evaluate, and because there are pluralistic sources of support out there. NSF is not the only source of support for funding. But I—my own feeling is we should err in that way, because of all these uncertainties, and don't get ourselves into some kind of fixed set of engagements with a set of institutions and—selected for good reasons in the first place, to say nothing of all the political issues which you referred to that arise whenever these things develop.

Mr. BOEHLERT. Thank you.

Mr. MACKAY. My concern, and this continues with what Congressman Boehlert was talking about, my concern is that this, it seems to me, we are sending a signal and the signal is we want you all to be more bottom-line conscious in basic research. We want you to go after industry.

I understand what industry says. I mean they take their—their most broad visioned person and they make him the one that negotiates with the university, but then when he comes back, they say, well, what did you get for us? And he better be able to say, well, we may get something out of here that will help this company.

Do you not have a concern that this is going to skew the research priorities in this country away from what has been the traditional research priority that we are looking for advanced—advancements in knowledge?

Dr. SHAPIRO. Well, I do have some of those concerns. I think those concerns are well taken. The issue of who it is that sets the scientific agenda determines just what problems the most creative and capable scientists are going to work on, I think is a very important point.

Mr. MACKAY. But you've got—when you make the application to NSF, you've got to say I have agreed to a partnership in setting my priorities. And if you don't say that, they are not going to give you the money.

Dr. SHAPIRO. Well, I think if they have—my own judgment is to proceed in any kind of arbitrary way like that is not going to be advisable in all circumstances. We are going to have to have lots of flexibility, depending on the area of science that we are dealing with, as to just what kind of partnerships we wish to create. And I think that any new effort with any new social rearrangement of the institutions and the research establishment are—are risks and benefits. And you are focusing on one of the risks, and I think we have to take that seriously and watch it over time.

Mr. MACKAY. All right.

Dr. SHAPIRO. But it's worth the benefits, because there is a return feedback which the academic world gets from its relationship with industry, as spoken to previously here this morning, and that can enhance the work that's done. It can improve the scientific agenda. But these are risks which have to be very much before us. I don't know that there's anything we can do except watch it and be careful. I think you have raised a very important issue.

Dr. GOLDSTEIN. We at Lehigh have two NSF university/industry cooperative programs which are much more tightly tied to industry, because at this point they are funding 90 percent of the cost of these centers. They are not—they are somewhat different than Engineering Research Centers. And the thing that we have gotten from these is excellent advice from industry on what the most important significant problems are that they have—that they're interested in.

I don't see them skewing our research so much as trying to help us understand where our research ought to go. I have not seen a time where our principal investigator, who is in charge of the center, walked away and said I won't do this, this doesn't make good sense. We have seen the faculty's interest channeled in very proper and interesting directions. And if the faculty aren't interested in this, we go and do something different.

I think that industry participation is much more important on the advice participation level of scientists going to industry, and industry scientists coming to universities, than it is in worrying about the dollars that they supply. The dollars will come, but they are not the most important thing when we are talking about the cooperation with industry.

Dr. WIDNALL. I think I'd like to make two points in this area. I think the first is that the level of university industry involvement will be enormously varied by field. I think it is almost impossible to conceive of a single model.

I think the reason that the research centers began in engineering is just the obvious reason, that that is where the interaction is likely to take place, perhaps the most easiest. It is the leading edge of the issue of economic competitiveness, and that was a good place to start.

The extension of these into the scientific area, I think, is going to be highly field-dependent. Again, I really stress again that individual universities are in the best position and individual faculty are in the best position to see how this additional—I see this as an additional research opportunity, not a replacement for the traditional individual and group projects in the fundamental sciences. But I think individual faculty are really in the best position to see what are the increased opportunities for their particular discipline.

In many fields of science and engineering, the industries have in fact the most up-to-date instrumentation. There are real opportunities in materials, electronic materials, and some of the biotechnology areas for the researchers in science to really actively get involved and use those facilities.

I think there may be some real opportunities in the marrying of plant genetics, microbiology and some of the issues in agriculture. There may be some major, major issues in that area that would be very exciting.

So I think it is going to be highly dependent on the field of science, and I don't feel that NSF is planning to move into this in sort of a blanket way, a sort of single model for these research centers. I think it is much more of an experiment in the area of basic science than it was in the field of engineering. And the field of engineering defines in such a way what the products of its research should be leading edge with respect to the application. And I think that that is not true in science, and I think—so we have to be much more experimental.

I would also make a point about the nature of industry/university cooperation in many of these fields, and I think President Gray said that this morning, that this often takes the form of a sort of a consortium, of very broad participation by the industry in the activities of a particular center. In very few cases does this turn into the direction of an individual PI (Principal Investigator). It really doesn't come to that. It becomes more an issue of sharing and cooperation rather than direction.

Mr. **Boehlert**. May I piggyback on that? When we're talking about industry center cooperation, address, if you will—we could keep you here all afternoon. This is an outstanding panel, but we won't do it and we can't. But foreign participation, pros and cons.

Dr. **Widnall**. I think we have a great deal of that at MIT. In fact, sometimes I think our Japanese involvement is larger than our NSF involvement, but that probably doesn't turn out to be true.

Again, I think the form of involvement normally takes the form of a foreign firm being a member of a consortium. We have at MIT something called the Industrial Liaison Program, which is sort of a membership organization where all firms pay a certain fee to belong to this consortium of industries, and there's a kind of free flow of information back and forth.

It does not involve any proprietary owning of the results of any research, any research project. It is more in the nature of the normal kind of open scientific communication that would go on in the university in any case. Foreign firms would have access to the results of research that go on at MIT by reading the journals, by sending graduate students. The benefits that they get from financially participating in the research, I don't believe really go beyond that, with the possible exception that there is a mutual sharing. They may send engineers to be in residence at MIT, and our people will work with those people, and there will be a fair amount of sharing and, I think, perhaps a mutual development of new ideas.

So I feel that's very healthy.

Mr. **Boehlert**. I would like to think in those terms, the mutual development of ideas, but I tend to think our perception, at least mine, is it's more one way. They benefit more than we seem to.

Dr. **Widnall**. I'm not sure that the Americans have been perhaps sufficiently aggressive at, you know, trying to make it more of a two-way street.

Mr. **Boehlert**. I would agree there.

Dr. Goldstein? Dr. Shapiro, would you address that?

Dr. **Shapiro**. I don't think I have anything further to add. I agree very much with the remarks that were made here. Obviously foreign firms or any firm doesn't—particularly foreign firms—don't contribute if they don't think they're getting something. They believe they're getting something out of this, and they are getting something out of it.

Mr. BOEHLERT. Sure.

Dr. SHAPIRO. Beyond what they would generally find in the open scientific literature. However, I think that we also get something out of it in our experience, and I think I agree with the remark that was just made, that if as many American firms were as aggressive about moving engineers abroad for periods of time and interacting with foreign firms, for example the Japanese firms that aren't coming here, that would be very helpful to us as a country, and I think that would be the preferable way to go, as opposed to just walling off ourselves in some kind of insular position.

But I very much agree with the point that was made.

Mr. BOEHLERT. Well, MIT is sort of a special case, because—well, you know why it's a special case. We don't have to elaborate.

Thank you all very much. It's been a very outstanding panel. It's helped me a great deal.

Thank you, Mr. Chairman.

Mr. MACKAY. I share the views that Mr. Boehlert has just expressed, and I would just like to say, Dr. Shapiro, you at one point made a comment about our preoccupation with things that are short-term. Essentially, I see the entire NSF budget as long-term, one of the very few things that this country is doing that is other than short-term, and I think in a way it's an indictment of this institution that we're having this much trouble seeing it that way and that we are struggling around with what is a fairly minor increase in what is a very minor part of our budget.

I hope someday we will figure out a way that we can say that, so that it becomes politically acceptable.

Thank you very much for this. I know that this was a major investment of your time, and it's been very helpful to us.

[Whereupon, at 1:05 p.m., the hearing was adjourned.]

1988 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

WEDNESDAY, MARCH 11, 1987

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Science, Research and Technology,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:42 a.m. in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the Subcommittee) presiding.

Staff Present: Robert F. O'Neill, David Goldston, Grace Ostenso, James Wilson and Maryanne C. Bach.

Mr. **Walgren**. This is the third hearing on the National Science Foundation's authorization for Fiscal Year 1988 and we are pleased to have with us this morning Erich Bloch, the Foundation's Director, to discuss with us the plans and the priorities for the new budget year.

In the previous hearings, we had comments by outside witnesses on the Foundation's role and activities regarding science, mathematics and engineering education at the pre-college and undergraduate levels; and we also had witnesses dealing with advanced scientific computing and the Science Foundation's industry programs and the interaction between industry and the National Science Foundation; and discussion of the balance between the multi-disciplinary grants and the individual-investigator grants, among other issues that come up in this area.

As everyone knows, the proposed NSF budget for Fiscal Year 1988 is a good, strong step; at least one might say it is noteworthy. It provides an increase of almost 17 percent above the previous year, and in these years, that is certainly noteworthy.

It ought to be said, though, that we have to measure all these efforts in view of the need, and certainly percentage increases are only an indication of direction, and depending on the adequacy of the base they may be meaningful or they may be less than meaningful.

It is also true that the Administration has proposed a doubling of the National Science Foundation budget by 1992, and that is an even more significant expression of commitment of the importance of this area. The implications of that kind of an increase for the mid and long-term run for the health of basic science and engineering research are certainly substantial, and on this Committee we are very gratified to see the Administration responding to the importance which we feel this area holds.

The National Science Foundation funds somewhere in the range of one-quarter of all the basic research that is carried out at universities, and as everyone knows, almost half of the basic research in the whole country is carried out at universities, so we're talking about a significant portion of an extremely significant part of the national effort in this area. Education of future scientists and engineers and support for basic research clearly are essential ingredients if we are to maintain our national momentum, our national security and our national economic strength as the world becomes increasingly small.

We are certainly pleased to have this opportunity to discuss with Mr. Bloch the programs and the direction that the Foundation is recommending, and we look forward to your testimony.

Let me recognize at this point the ranking minority member, Mr. Boehlert.

[The prepared opening statement of Mr. Walgren follows:]

OPENING STATEMENT OF CONGRESSMAN DOUG WALGREN, CHAIRMAN, SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

This is the third hearing on the National Science Foundation's authorization for fiscal year 1988. We are pleased to have with us this morning, Erich Bloch, the Foundation's Director, to present plans and to discuss priorities for the new budget year. Previous hearings held on February 19 and February 25 allowed for comments by outside witnesses on the Foundation's role and activities regarding science, mathematics and engineering education at the precollege and undergraduate levels; advanced scientific computing; NSF/industry programs and interactions; and the balance between multi-investigator, multi-disciplinary grants and individual investigator grants.

The proposed NSF budget for fiscal year 1988 is particularly noteworthy. It provides for an increase of almost 17% above the previous year and is the first of five increases proposed by the Administration to produce a doubling of the NSF budget by 1992. The implications of this planned increase for the long-term health of basic science and engineering research in the United States are immense. NSF funds one quarter of all basic research carried out at universities, where nearly half of all basic research is conducted. Education of future scientists and engineers and support for basic research are essential ingredients for maintaining national security and for ensuring economic competitiveness in an increasingly global marketplace.

Mr. Bloch, we are pleased to have this opportunity for discussion of the Foundation's programs and the new initiatives to be made possible by the proposed growth in the fiscal year 1988 budget.

Mr. BOEHLERT. Thank you very much. Woody Allen once began a commencement address with a statement, "Today, we are at a crossroads; one road leads to destruction and despair, the other to total extinction. Let us pray we choose wisely."

Well, the National Science Foundation is at a crossroads, too, albeit one that is far less bleak. But wrong choices by NSF or this Committee could send the Foundation careening down dangerous paths. Some paths lead only to research; others only to education. Some lead to research that is too pragmatic; others to research that is too rarefied. Some lead to estrangement from industry; others to estrangement from academia. All these paths must be rejected.

What we must do, and clearly this has been NSF's intent, is to navigate between those extremes. But as evermore funding enables NSF to build up steam, we must be evermore careful we don't inadvertently veer in any of the wrong directions.

That NSF should be allowed to grow seems to me incontrovertible. We have before us an agency of proven ability that contributes immensely to our nation's well-being. Long before competitiveness was in vogue, NSF was there supporting the research that underpins our productive capacity. Long before the words "education crisis" appeared in our headlines, NSF was bolstering all levels of science and mathematics education.

The National Science Foundation has earned our continued support, and I think that, in cooperation with Mr. Bloch, we can steer NSF through the current crossroads without even nearing despair, destruction or extinction.

Thank you, Mr. Chairman.

[Prepared opening statement of Mr. Boehlert:]

OPENING STATEMENT OF HON. SHERWOOD BOEHLERT

Mr. Chairman, Woody Allen once began a commencement address with the statement: "Today, we are at a crossroads. One road leads to destruction and despair; the other, to total extinction. Let us pray we choose wisely."

Well, the National Science Foundation (NSF) is at a crossroads—albeit one that is far less bleak. But wrong choices by NSF—or this committee—could send the Foundation careening down dangerous paths.

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The National Science Foundation has earned our continued support. And I think that, in cooperation with Mr. Bloch, we can steer NSF through the current crossroads without even nearing despair, destruction or extinction.

Mr. WALGREN. Thank you, Mr. Boehlert. I can't let a reference to Woody Allen go by without my own memories of his crossroads in the movie that was a takeoff on the Brothers Karamazov, or something like that. Or maybe it was The Idiot.

[Laughter.]

And the story was that—we can go off the record for this.

[Laughter, and Discussion off the Record.]

Mr. WALGREN. Back on the record. The Chair recognizes Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman. I would like to echo the comments of the ranking member and I'm sorry I was late for the opening statement of the Chairman. I, too, have great respect for the achievements and the accomplishments of the National Science Foundation, and among government agencies supporting research and development I think they have done an outstanding job.

I think, however, within all the laudatory comments we also should take heed that the selection of the arenas of basic science is not necessarily one that occurs in a vacuum, and those areas of basic science which underpin the technological advantage of the United States, the potential for commercialized products in the global marketplace, is something that we should be attuned to and that it doesn't occur in random fashion, it occurs with decision-making from a National Science Board which has a view towards commercial products, which has a view towards the international competitiveness issue, which has a view towards the private sector.

I think I have said enough, Mr. Chairman, thank you.

Mr. WALGREN. Thank you, Mr. Ritter.

Your written statement will be made a part of the record, as is our process, and please feel free to select from it or outline, underscore in any way what you feel best makes the points that you would like to direct our attention towards. We are glad you are here, Mr. Bloch.

STATEMENT OF ERICH BLOCH, DIRECTOR, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY DR. JOHN MOORE, DEPUTY DIRECTOR, NSF

Mr. BLOCH. Thank you, Mr. Chairman, Mr. Boehlert, Mr. Ritter, for your comments. I will not try to match the Woody Allen joke, so let me go into a short statement that pretty much follows the written one but it is a lot shorter. Also, Dr. John Moore is here at the table, Deputy Director of the National Science Foundation.

I would like to say first, before I make my statement, how much the Foundation and the science and engineering community generally have appreciated the support of this committee over the years, and also the support of the members, and especially that of the Chairman.

I would like to pose a few questions, of which the first is, "Why this concern with economic competitiveness?" The answer is that for too long, we have tended to see our economic problems as a result of forces largely beyond our control, such as unfair trade practices, low wages in other countries or unfavorable exchange rates. The new concern with competitiveness makes us realize that the most important thing is simply to stay ahead of our competitors. We can succeed if we look to our own resources, of which the most important ones are knowledge and well-educated people. They are the key elements of the competitive technology.

New knowledge is important because it provides ideas for new products that we need to compete in high technology areas as well as in low technology areas. Education is important because talented and well-trained people are the source of the ideas and the main resources needed to put them into practice. New knowledge and education are prerequisites for economic strengths. Other factors must contribute, obviously, but these two are fundamental underpinnings to everything else that we are doing.

Now, where does NSF fit in? First of all, the concern with the long term means concern with all parts of the science and engineering base. The Foundation is the only Federal agency with such broad responsibility for basic research and education. NSF encourages research on the boundaries between established disciplines where some of the economically most significant problems arise. NSF supports mathematics, science and engineering education at all levels in ways that link education and research; a very important combination.

Mr. WALGREN. Let me stop there and ask you to pull that mike really in. These mikes are very directional. I think that was designed to prevent side comments up here from being picked up, but they really need to be right into the mike for the people in the back to hear. I apologize for interrupting.

Mr. Bloch. I will try not to swallow it.

The third point I want to make is that NSF encourages cooperation between universities and industry, and among federal, state and local governments. NSF, finally, supports developing institutions and regions, undergraduate institutions, and broader participation by minorities and women.

It is a major strength of our system that basic research and education take place together in our universities, but this makes it essential that we increase our investment in these institutions, and that is the central idea behind our Fiscal Year 1988 budget request.

What has been done already to use research and education to make us more competitive? And as you, yourself, pointed out, Mr. Chairman, and Mr. Ritter, quite a lot. Our budget request is in line with rising support by the Administration and Congress for basic research over the last seven years. Total Federal support for research and development has nearly doubled since 1980, and outside of the defense effort, a much larger share now goes for basic research. With strong bipartisan support, the overall budget for the Foundation has also risen, ending a long period in which it was flat.

Despite these actions, we still have serious problems with research and education. When compared with our trading partners, the United States ranks only fourth among the industrialized countries in the fraction of gross national product invested in civilian research and development. The fraction of Federal R&D that goes to basic research and to university R&D has been dropping; both of them have been dropping, as a percent of the total Federal R&D budget, even though the increases have been significant, that I cited before. And I'm showing that in my written statement as Chart 5 in your attachment (see written statement).

Furthermore, too few of our students are choosing science and engineering careers, and too few of those who do, continue to the Ph.D. That is not the way to be competitive. We must invest more in our science and engineering base if we want to solve our economic problems.

Let me talk about the 1988 budget request, and you mentioned already, Mr. Chairman, that we are asking for $1,893,000,000, and that is almost 17 percent above our appropriation for the current year. In addition, the Administration is committed to increases that will double the NSF budget over the next five years. And in a significant departure from past practice, we have submitted a five-year authorization bill for your consideration as Title II of the President's Competitiveness Initiative.

These increases establish a strong base from which to plan expanded support for education and university basic research.

The budget proposal that we submitted emphasizes three major themes, of which the first is education and human resources. People are our most important resource. Reflecting this priority, our budget proposes a 50 percent increase for education and human resources. The Foundation has always been involved heavily in education efforts, but this year's proposal represents a much broader commitment. Let me stress that word "commitment." In 1983, the Science and Engineering Education Programs were 1.5 percent of the Foundation's budget, and I must say it was a low point. In 1988, the SEE programs will be 6.1 percent of the total, and they will grow more rapidly as our budget doubles over the next five years. They are only part of our overall human resources effort.

I have added Figure 5 to the written testimony to make that particular point. I'm sorry, Chart 7 (see written statement).

Just as important as commitment is the linkage between education and other programs in NSF. Why is this linkage important? Because only tight connections between research and education can ensure that education remains relevant and up to date in the rapidly changing world of science and technology. This is important in our universities. It is just as important at NSF.

Linking research and education does not mean that the differences between them are blurred or that it is not possible to identify clearly the specific uses to which funds are put. We have well-established procedures for tracking funds that are spent through the research directorates for special purposes and we do that all the time.

In 1987, our Education and Human Resources effort totals $182 million, of which 46 percent is spent through the research directorates; in 1988, 58 percent is being spent through the research directorates. Altogether, Education and Human Resources activities will be over 14 percent of the total NSF budget in 1988, and these numbers demonstrate both commitment and the linkage that I have talked about.

They also demonstrate, if it is necessary, that our education programs belong where they are and not in the Department of Education, as has been suggested.

Let me turn to undergraduate initiatives. As you are well aware, the National Science Board, the Science and Engineering Education Advisory Committee, and academic groups have recommended much stronger efforts directed at undergraduates. We have listened to this advice. An increase of $38 million to undergraduate-related programs will more than double the resources allocated to this area. Funding for undergraduates participating in research will double, specifically.

Support for instrumentation for undergraduate use will more than double; curriculum projects in calculus and engineering and a major program of faculty enhancement will be undertaken. These are significant changes. And as I stated to you in a recent letter, I am establishing an Office of Undergraduate Education as a part of the Science & Engineering Directorate to coordinate this agency-wide effort.

Outside of the undergraduate area, we will increase human resources support by $53 million. This will support greater efforts at the pre-college level, an increase of 200 annual graduate fellowships, more support for Presidential Young Investigators, and renewed efforts to encourage greater participation by minorities, women, and disabled persons.

These are important programs. They demonstrate the Foundation's role in the Nation's science and engineering education. But that role must be kept in perspective, especially at the pre-college level. The Foundation provides less than a tenth of a percent of the nation's overall education budget. For science and engineering education alone, it is still much less than one percent.

At the pre-college level, the states and local governments have the main responsibility. In a few areas with great leverage, like television programming and curriculum development, the Foundation can provide a significant fraction of the resources. But we cannot equip the Nation's school laboratories or train the teachers. We can stimulate, we can exemplify and we can demonstrate and we can catalyze, as we do with Model Teacher Training Programs and other programs in the Foundation, but the basic resources must come from others.

The second theme is support for Science and Technology Centers, which will receive an increase of $80 million. There will be additional Engineering Research Centers and centers for biotechnology, material science and computer and information sciences. These centers are located at universities; they are multi-disciplinary and they are organized with strong industry involvement. They do basic research on problems, and I want to stress that. They are not doing product design; they do basic research on problems that are important to science and important to competitiveness.

This is a program that the President announced recently in his State of the Union and Quest for Excellence messages. These centers are also part of our strategy for developing human resources because they involve both graduate and undergraduate students in research that is current in the industry in which they will soon find employment.

Finally, the movement of students to industry and of senior researchers in both directions is one of the most effective ways to move knowledge out of the laboratory, out of the university laboratories, and apply it in economically significant ways.

The third theme of this budget is the steady improvement of the Foundation's broad support for disciplinary programs and facilities, and for the principal investigators. These will be increased by $99 million. This is important because by its nature, basic research is unpredictable. One cannot say in advance where break-throughs with major economic importance will be found. Support for centers and support for disciplinary programs are complementary ways to support research. Neither one or the other is sufficient by itself; it is a matter of striking the right balance.

Mr. Chairman, the President announced a major initiative that sets the United States once again on a quest for excellence. He said that our policies must serve three objectives. First, they must generate new knowledge in science and technology. Secondly, they must swiftly transfer that knowledge to the marketplace. And third, they must expand our Nation's talent base in science and engineering. End of quote.

These are objectives that will be met in part through the programs of the National Science Foundation, but they are long-term challenges that will be met only by a long-term commitment to strengthen our science and engineering base. The significance of this budget is that it makes that commitment. Thank you very much.

[The prepared statement of Mr. Bloch follows:]

TESTIMONY OF

MR. ERICH BLOCH

DIRECTOR, NATIONAL SCIENCE FOUNDATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH & TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

WEDNESDAY, MARCH 11, 1987

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE:

Good morning. I am glad to have the opportunity to provide an overview of the National Science Foundation's budget proposals for 1988, to discuss their relation to the nation's economic competitiveness, and to discuss a few additional topics of particular interest to this subcommittee.

First, let me express appreciation for the continued support that this subcommittee has shown for the importance of education and basic research in science and engineering. Your understanding of the links between research, education, and the welfare of our nation has been demonstrated by your willingness to recommend the needed investments in these areas which are important to advancing our economic competitiveness position.

It is high time that economic competitiveness moves to center stage. For too long we have tended to see the source of our economic problems as the result of unfair trade practices, or low wages in other countries, or unfavorable exchange rates.

Recently we have realized that if we want to compete successfully as a nation, the most important thing is to stay ahead of our competitors in continually generating new ideas through basic research, and turning them into high quality, innovative products and services for the market place. Many forces must come together to achieve economic competitiveness, but prerequisite is a viable infrastructure that is capable of educating our people and generating new knowledge.

Basic Research and Competitiveness

Colleges and universities are the principal instruments for development of these assets. They provide ideas and new knowledge for the products that we need to compete in high-technology areas, and the concepts and ideas that can raise productivity in low-technology manufacturing and service industries.

In fact, technological innovation achieved through research has been responsible for nearly half of all productivity gains since World War II. Research results can take their place side by side with economies of scale and other productivity enhancement parameters.

Many of NSF's programs can be directly tied to these driving forces: robotics, engineering research centers, biotechnology, materials research, education of future scientists and engineers, and many more. Seeking productivity through research and technological innovation is the way we should enhance our position in international and economic competitiveness. It is far preferable to reliance on trade barriers or other protectionist measures.

The Science and Engineering Enterprise

The science and engineering research base on which we depend consists of three elements: people, facilities, and equipment. Of the three, people are by far the most important. Well trained people are the source of the ideas and the knowledge which make technological innovation possible. A dynamic, productive economy demands a steady flow of new ideas and well-educated people to generate successful products.

Adequate facilities and equipment can be obtained relatively quickly -- it only takes money. The creation of a scientist or engineer takes many years--the process begins in the precollege years and continues through undergraduate and graduate training.

The length of time this requires makes it imperative that we continuously attract the most talented young students into science and engineering programs. Interruptions in this process take many years, even decades to overcome.

We cannot depend on market demand to ensure an adequate supply of scientists and engineers, for the market fluctuates much too rapidly. The educational system cannot respond quickly when demand goes up, and finds itself producing surpluses when demand is down.

The Role of NSF

The government's ability to affect our competitive position is limited, since for good reasons much of the initiative and responsibility rests with the private sector. There is one area, however, in which the government's role is both necessary and clearly beneficial: the support of education and basic research.

That is why the National Science Foundation plays an increasingly critical role in the national quest for economic competitiveness. NSF does this by providing linkages among the vital elements of the science and engineering enterprise:

- NSF not only supports research, but education;
- It not only support basic research in the sciences, but also in engineering;
- It supports the nation's top research universities, but reaches out to undergraduate institutions, high school and elementary schools as well; and
- It does not operate in isolation but demands the active involvement in both planning and funding of private sector entities, state and local governments, and universities themselves.

The FY 1988 Request

Our budget request for Fiscal Year 1988 is $1.893 billion. That is a substantial 16.7% above our appropriation for the current year. Of equal importance, the Administration is committed to increases at a rate that will double our budget, to a level of 3.2 billion dollars, by 1992 (Chart 1).

These increases, projected over a five year period, establish a strong base from which to expand support for education and university basic research and plan for the future. This is a major departure from the past. It reflects the need to rebalance our effort in research and development. This cannot be done in one year alone. It also reflects the nature of education and research--many of the proposed programmatic thrusts are spread over many years, even decades. Stability of funding commensurate with the time horizon of programs and initiatives allows for much better planning.

NSF's budget request should not be judged in isolation. It must be considered as part of the total Federal research and development budget, in fact as part of the total U.S. research and development effort (Charts 2-4).

Since 1980, federal support for research and development has nearly doubled, going from $33 billion in 1980 to about $63 billion in 1987. The fraction of the civilian-oriented effort devoted to basic research has risen in that time from about 26% to about 39% With strong bi-partisan support, the overall budget for the Foundation rose 66% between 1980 and 1987, ending a long period in which it was essentially flat.

These actions have been beneficial; but, we are continuing to experience serious problems:

- Basic research is dropping as a proportion of total federal R&D. It is also shrinking in the private sector (Chart 5).
- We see increasing research competition from our trading partners (Chart 6).
- We see shortages of scientists and engineers developing in some fields.
- Our production of scientists and engineers is not keeping up with that of our international competitors. And,
- Facilities and instrumentation in universities need modernizing.

We can only conclude that a significant increase in education and basic research support in our universities is needed.

Our budget proposals for 1988 are focused on dealing with these issues and giving a renewed emphasis to basic research and support for universities.

Three major themes are emphasized in this budget:

- Education and human resources;
- Basic science and technology centers; and
- Disciplinary programs and facilities.

Education and Human Resources

The first theme is education and human resources. The nation's science and engineering base -- the source of our ability to do basic research and to develop new technologies -- is made up of people, equipment and facilities. Of the three, people are the most important.

I do not need to recite the findings of several recent national studies and international comparisons which highlight alarming shortcomings in our education infrastructure, and in science and mathematics achievement among our students. And we know the demographic data that show us a future with proportionally fewer young people, our most basic resource.

We must act to address these serious concerns about the quality and quantity of the talent pool we need to sustain a vital scientific and technical enterprise in this nation.

The National Science Foundation proposes significant growth in support for education and the development of human resources, from $182 million in FY 1987 to $273 million in FY 1988.

Attention is given to the precollege, undergraduate, and graduate education areas. NSF has different responsibilities at each of three areas of the educational spectrum.

In precollege education, the feeder for all science and engineering talent for the country, the center of gravity of support and policy is in the thousands of localities across the country, the state governments, and--on the federal level--at the Department of Education. Yet our influence can be large. Our programs are designed to catalyze, to demonstrate, and to mobilize interest from other participants. The Foundation's resources are small compared to the total resources available and need to be judiciously applied. For FY 1988, the President's mandate that NSF, in conjunction with the Department of Education, address mathematics, science, and computer literacy for the country's children will be a major focus.

Areas of NSF emphasis are ones where the potential for significant leveraging of our investment is present. Examples include:

- New materials development;
- Inservice and preservice teacher training;
- Early experiences to stimulate interest in science and engineering;

- Informal (e.g., television, museums) education beginning at the very earliest school years; and

- Focus and recognition for teaching excellence (e.g., the Presidential Awards for Excellence in Science and Mathematics Teaching).

Foremost however, the involvement of the NSF can guarantee the participation of the university research community in precollege education.

Undergraduate education in science, mathematics, and engineering has been singled out by the recent report to the National Science Board as demanding major attention. NSF's role will be one of focusing on:

- Research experiences for undergraduate students and faculty as part of its disciplinary research projects and centers;

- Curriculum development, beginning with calculus and engineering; and

- Instructional and research instrumentation for use by undergraduate faculty and students.

This is a new approach for NSF with respect to organizing our support for undergraduate research and education in science and engineering. All directorates will have a role and the effort will be coordinated for the Foundation as a whole by the Science and Engineering Education Directorate.

Graduate education has always been a major focus of the Foundation through its prestigious Graduate Research Fellowships Program and its support of graduate students through ongoing research awards. Support beyond the graduate level has included postdoctoral research associates, postdoctoral fellowships where special needs exist, special seminars and conferences, research initiation efforts, and the Presidential Young Investigators program.

Throughout the planning process and the development of the budget request before you, focus has been on balance across the educational spectrum to attract, educate, and retain the technical personnel we need for our future, We have used the principles of excellence and opportunity for participation by all our citizens, regions, and institutions to build a strong, comprehensive approach.

The table below shows the distribution of funds for this effort:

EDUCATION AND HUMAN RESOURCES

Undergraduate	$ 68.0 Million
Instrumentation/Laboratory Development	22.0*
Research Experience for Undergraduates	18.0*
Faculty Enhancement	11.0*
Curriculum Development	7.0
Research in Undergraduate Institutions	10.0
Other Human Resources	**$ 205.0 Million**
Precollege	68.0
Graduate/Postdoctoral	54.5
New Investigators	52.0
Broadened Participation	30.5

* Planning estimates. Final distribution will depend on proposal pool. Some projects may combine efforts for laboratory instruction, faculty and student development.

Under this effort, existing programs will continue, and expand, and new activities will be supported:

- Precollege emphasis on teachers, materials, advanced technology, and informal science education continues. New activities for high ability high school students will be implemented.

- Support for undergraduate activities more than doubles, with new activities for faculty and curriculum development, and significantly enhanced programs for instrumentation and students.

- 200 additional new Graduate Fellowships will be awarded, and the number of Presidential Young Investigators will increase by 200.

- New activities will be introduced to increase the number of women and minorities participating in science and engineering.

I want to emphasize that this effort in education and human resources will be supported throughout the Foundation. Over the past three years, the Foundation has placed increasing emphasis on addressing significant cross-cutting issues through all its programs. We have developed coordinating mechanisms, and established tracking and monitoring systems. This cross-directorate approach will be followed in the proposed activities for education and human resources.

The Science and Engineering Education (SEE) Directorate will continue its primary emphasis on precollege education, instructional laboratory equipment for undergraduate institutions, and the prestigious program for graduate fellowships (Chart 7). It also has the prime responsibility for bringing the President's mandate referred to above a reality.

I firmly believe that the Foundation's disciplinary research directorates must be responsible for the health of their science and engineering disciplines -- including concern for the underlying education and human resources infrastructure. The most effective activities in this arena will reflect the particular needs of specific disciplines and research areas. Therefore, the undergraduate initiatives, like many of the efforts focused on participation by minorities, women, and the disabled, are distributed across NSF, with central monitoring and fiscal control.

We have already seen the success of this approach in the program for Research in Undergraduate Institutions. The new program for Research Experiences for Undergraduates, introduced just last December, is already drawing enthusiastic response.

It is also important to recall that in addition to these focused efforts for education and human resources, the Foundation continues its substantial support for undergraduate and graduate research assistants on NSF research projects -- fostering in another way the critical link between education and research. In FY 1986, more than $115 million supported over 3,000 undergraduate and 12,000 graduate students in this fashion (Chart 8). This support will grow to an estimated $145 million in FY 1988 through proposed increases for science and technology centers and basic disciplinary research programs.

Basic Science and Technology Centers

The second theme is the establishment of basic science and technology centers. These are university-based, multidisciplinary research centers--each with strong industry involvement--working on problems that are scientifically important and can, in the long term, contribute to advancing our economic competitiveness. This is the program that the President announced in his State of the Union address.

The close coupling of industry with academic research that these centers provide has the potential to substantially improve technology transfer from research labs to industry and to the marketplace.

At the same time, these science and technology centers will play an important part in the education process because they involve students, both graduate and undergraduate, in research on important problems. The result of that research will find its way into improved curricula.

The proposed $50 million increase will be applied to the establishment of new centers based on the proven concept of the engineering research centers. These would include additional ERC's, biotechnology centers, and centers for materials science, social and behavioral sciences, and computer and information sciences.

Disciplinary Research Programs and Facilities

The third theme of this budget is the steady improvement of the Foundation's traditional broad support for disciplinary programs and specialized research facilities. For these activities, we are proposing an increase of nearly $100 million, with special focus on global geosciences, biotechnology, and materials science and engineering.

Solid support across all the disciplines is important because, by its nature, basic research is unpredictable; one cannot say in advance where a breakthrough with major economic importance will be found. But we know from experience that they will be found.

Let me give you an example of that that I found striking: a problem in basic research in astronomy a few years ago was to develop calculations that could determine the properties of objects that are occluded by the moon. No one could have predicted that this same process of calculation would become the basis of an important modern medical technology called computerized axial tomography: the "CAT" scan.

These jumps from basic research to applications can almost never be foreseen, but they have happened so frequently in the past that we can be confident of the ultimate value of the investment.

Now I'd like to discuss several topics of special interest to this subcommittee--the NSF proposal review system, balance in the support of projects, and monitoring our cross-directorate education and research thrusts.

Merit Review

The Foundation is very proud of its competitive proposal review process. The core of this process is the judgment of qualified, experienced scientists and engineers in identifying promising, high quality research and education projects worthy of support. This system has been subjected to periodic examination by internal task forces and outside panels, including Congressional committees. It has been found to be remarkably effective and flexible, adapting to the changing needs of science and engineering, and incorporating improvements with respect to openness, accountability, equity, and impact on the research and education environment.

At NSF there are more than 200 individual programs managed by some 300 program officers, about a third of whom are on leave from their universities or other organizations. Program officers are recruited for their knowledge and experience and they interact constantly with the research or education community of which they are a part. They are experts in their fields and are well aware of the opportunities and needs in their areas. They administer the proposal review process and use its results to form the basis for their recommendations for support of projects. Their recommendations are, of course, reviewed by higher level officials, and if the award recommended exceeds $1.5 million for one year's support, by the National Science Board.

NSF's review process includes participants from the broad community of highly qualified scientists and engineers--men and women, white and minority, large research institutions and smaller undergraduate-oriented colleges and universities, federal laboratories and industry, and from all geographic regions. We take the fairness issue very seriously and conduct an annual statistical analysis to identify real or apparent biases.

Since 1974, NSF has used four criteria for selecting projects: research performance competenco, intrinsic merit of the research, utility or relevance of the research, and effect of the research on the infrastructure of science and engineering. The excellence of the science of engineering being proposed is THE major factor for selection. Once that has been established, the secondary criteria are used. In 1986 the NSF Advisory Committee on Peer Review chaired by Dr. Norman Hackerman, President emeritus of Rice University and former Chairman of the National Science Board, affirmed the fundamental health of the present system. Recognizing the evolution of the perr review process at NSF, it recommended adoption of the term "merit review" as a more accurate description of the present process.

In the last few years there has been an increase in interdisciplinary research proposals. This is a reflection of the growing numbers of research problems which require the combined expertise of scientists and engineers from several disciplines. Such proposals present special problems for a system which has traditionally been structured to handle proposals which are single discipline in nature. Different organizational arrangements for administration and different review procedures are required, as was the case with the

Engineering Research Centers Program. The process we instituted involved a multi-stage, interdisciplinary review of ad hoc panelists, a site visit team, and a final "blue ribbon" panel.

Monitoring Project Balance

One of the issues which has recently become of great concern, not only to this subcommittee but to many in the academic research community as well, is that of balance among the various modes of support for research. As the area of multidisciplinary research has grown and as the cost of research equipment has continued to increase, we have seen a shift in the proportion of resources devoted to collaborative research projects. As this has happened, concern about the funds that go to individual investigator projects has been expressed.

The facts are that individual investigator awards constitute by far the largest portion of the NSF budget (about 60%), and reflect our commitment to maintaining the basic research capability of the Nation across the full spectrum of science and engineering disciplines. These awards promote flexibility and spontaneity which often foster scientific breakthroughs.

At the same time, much basic research over the past decade has moved in the direction of collaboration and concentration of resources. Much of this change is driven by the nature of scientific inquiry itself rather than just the increasing costs of doing forefront research.

Technologies such as satellite communication and large scale computing and computational techniques enable scientists to work with data sets of greater size and complexity than ever before possible. The leading edge of modern scientific effort is more and more at the intersections of traditional disciplinary boundaries: astrophysics, biotechnology, atmospheric chemistry, materials science and engineering for examples are emerging "fields" which require expertise from more than one discipline.

The fraction of the NSF budget devoted to collaborative research has been growing over the past several years in response to the trends noted above. In many cases, scientists who would have worked alone or with a graduate student or postdoc now find themselves interested in problems which require association with other investigators, and the use of large scale facilities and specialized instrumentation.

Centers such as those initiated under the Engineering Research Centers program are a natural evolution of the trend toward interdisciplinary collaboration to address complex and urgent science and engineering problems. In addition, centers provide unique opportunities for education and technology transfer as well for involving the private sector, states and localities, as active partners.

Let me assure you that this matter of balance is of great concern to us as well. It receives careful consideration at every level, from individual program to senior management and the National Science Board, and is a major element in the deliberations of our advisory bodies. This year one of the National Science Board's Task Committees is specifically devoted to examining the centers/individual support modes, including the issue of arriving at a proper balance between them.

The continuing rebalancing between centers, groups, individual grants, instrumentation, and facilities is driven by the demands of science and engineering, the emergence of new disciplines and research approaches. The current proportions among these various modes reflect our judgments about the dynamic forces in today's research as well as the fundamental relationships which underpin the long term health and vitality of the science and engineering enterprise. As in all changes, what is the emerging golden age to some, is threatening to others.

Managing Cross-Directorate Efforts

As more and more of the Foundation's efforts become not just multi- and interdisciplinary, but also cross organizational units, the issue of tracking and monitoring our expenditures in these areas becomes very important. We see this in areas such as our distributed minority and women's programmatic efforts, the computational science and engineering initiative, the global geosciences activities, and others. Concerns about tracking and monitoring raise issues of accountability, how we can judge success or failure, and others. Over the past several years we have devoted significant time and effort to designing, developing, and implementing a system that responds to these concerns.

Two types of tracking and monitoring take place: 1)proposals and awards in cross-directorate programs and activities and 2) participation of underrepresented groups in NSF programs and as members of peer review and advisory panels.

With regard to the tracking and monitoring of cross-directorate proposals, the experience we have gained in mainstreaming the research in predominantly undergraduate institutions initiative,Minority Research Initiation and Research Opportunities for Women programs has paid significant dividends in extending the concept to other NSF programs. In 1987, the tracking system has been extended to include Research Experiences for Undergraduates.

New procedures for coding proposals have been established are now in place throughout the Foundation. Our Management Information System now generates detailed monthly reports on cross-directorate activities. These reports are used by program and division level staffs to monitor their progress in meeting funding targets for special program activities. Quarterly reports are prepared to assess progress toward targets across the Foundation. These are discussed at directorate quarterly reviews and at Executive Council. One aspect particularly important to note is that this system now allows us to electronically designate funds to be used only for the purposes of these special activities.

For the first time, we have in place a system that allows us to monitor on a real-time basis the specialized characteristics of the proposals we receive and the awards we make. We intend to use this basic coding scheme to track our efforts in other areas such as computational science and engineering, biotechnology, and global geosciences.

For some time we have discussed with this subcommittee our efforts to obtain information on the representation of women, minorities, and disabled persons as proposers, awardees, peer reviewers, and advisory committee members. Our progress has been slower than we would have hoped but I am pleased to tell you that the system is now in place, operational, and we are able to extract data from it.

In December 1985 NSF issued an important notice to colleges and universities requiring the submission of a form which records data on gender, ethnicity, and disability status. The submission of the data is voluntary, submission of the form is not. After a complete year's experience, we now know that for gender data, the response rate for submitting the data was 99% and the percentage of proposals submitted by female investigators was 12%. Similarly we know that the response rate for racial/ethnic data was almost 90% and about 2% percent of the proposals were submitted by minorities underrepresented in science and engineering.

In a related vein, in January 1987 NSF issued an important notice to colleges and universities about the collection of data about personnel who received support on NSF awards. As a part of the final project report required for every NSF award, summary data will be submitted on PI's, postdoctorals, graduate and undergraduate students, precollege teachers, and foreign students. Summary statistics will be available by gender, race, and disability. While it is obviously too soon to predict what sort of information we will get, we are encouraged by the cooperation that we have received from the academic community on our previous data collection efforts.

Summary

In summary, the NSF budget for Fiscal Year 1988 and future years will allow the Foundation to improve research and education in our universities and colleges in very important ways through:

- basic science and technology centers;
- mathematics, science, and engineering education at all levels of the educational pipeline;
- broader participation of institutions and underrepresented groups;
- cooperation between federal and state governments, industry, and academia; leveraging taxpayers' dollars in the process; and,
- transfer of research results from universities to industry.

Mr. Chairman, all these activities are important for the long term economic health of our nation. Through them, the Foundation will make significant improvements in research and education at our universities and colleges.

Even more important, the Administration's commitment to doubling of the NSF budget will keep education and basic research in science and engineering on a steady upward track. I believe strongly that nothing is more important for the long term economic health of our nation. I look forward to working with you and with the entire Congress to make sure that these proposals are turned into actions.

Chart 1

NATIONAL SCIENCE FOUNDATION
OBLIGATION TRENDS

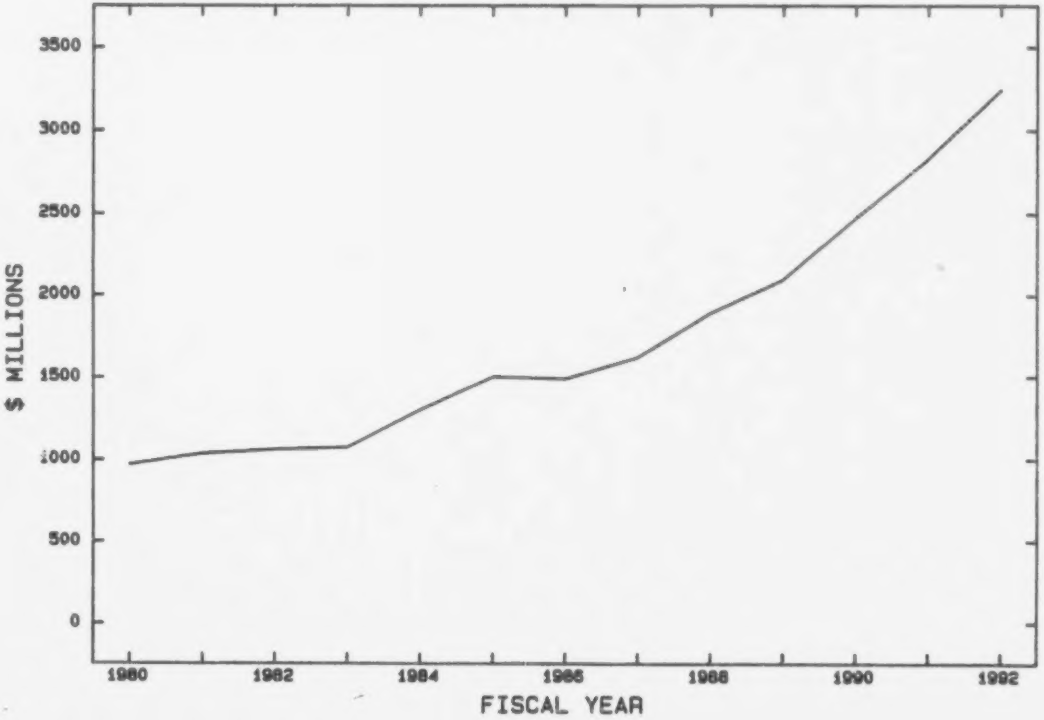


CHART 2

NATIONAL EXPENDITURES
FOR RESEARCH AND DEVELOPMENT

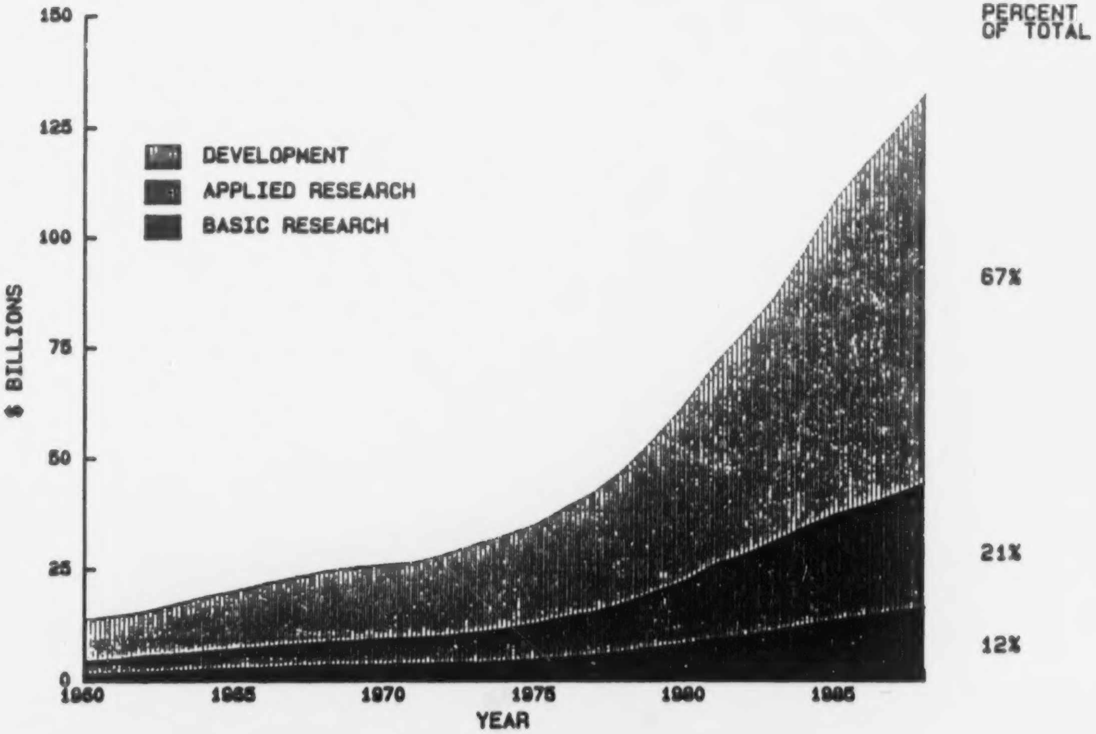


CHART 3

Research and Development
1987

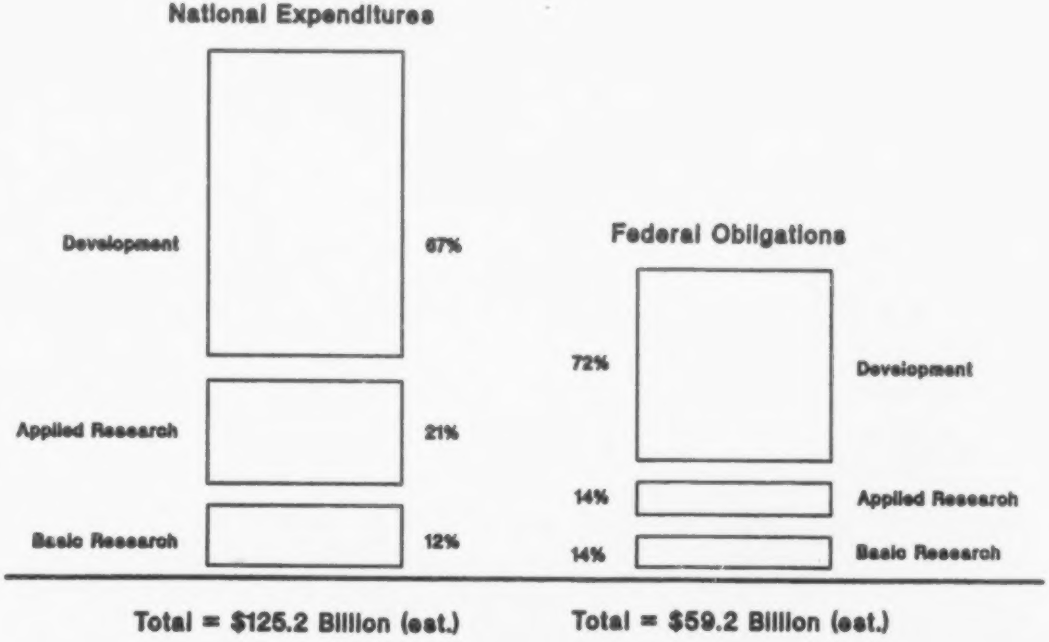
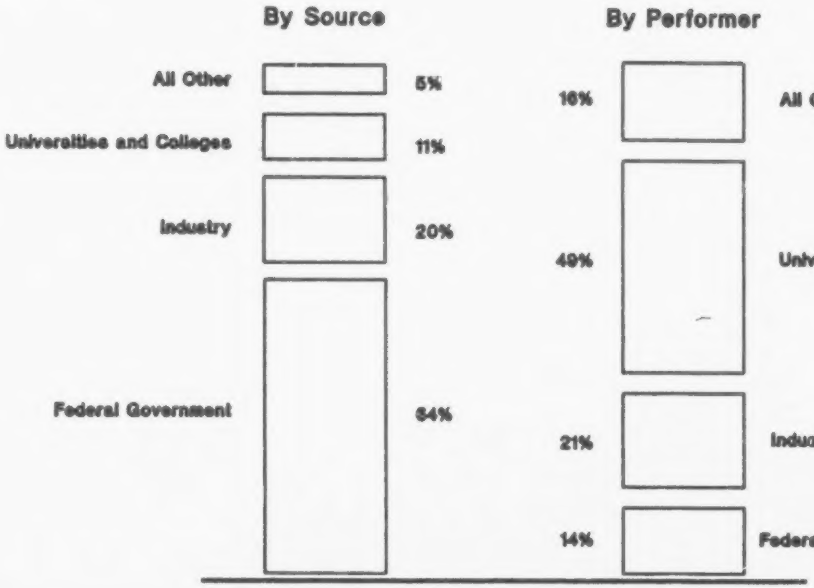


CHART 4

National Expenditures for Basic Research



Total 1987 Expenditures = $ 15.3 Billion (est.)

CHART 5

BASIC RESEARCH
– AS A PERCENT OF TOTAL R&D –

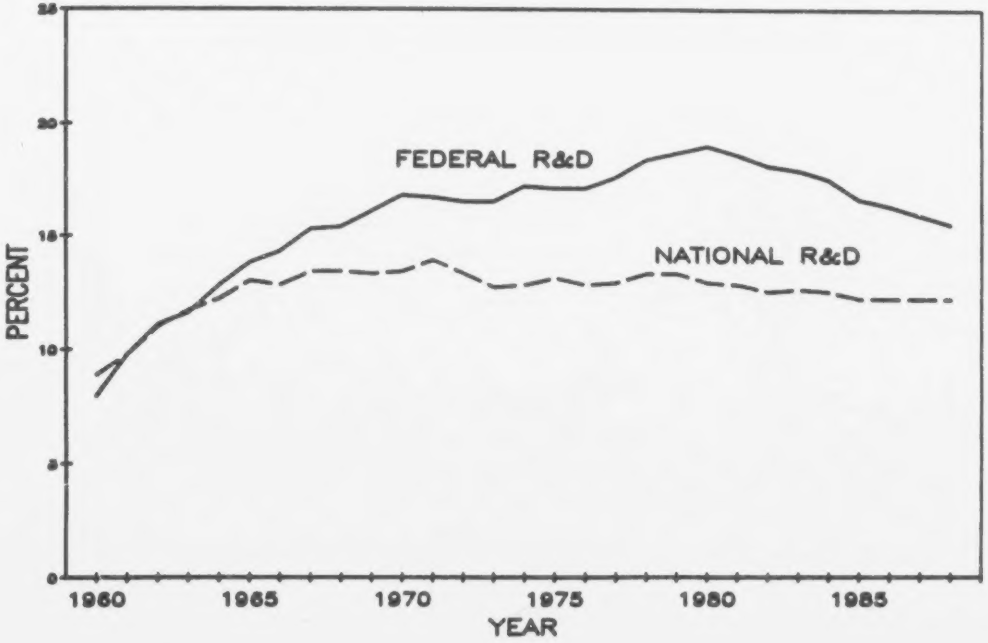
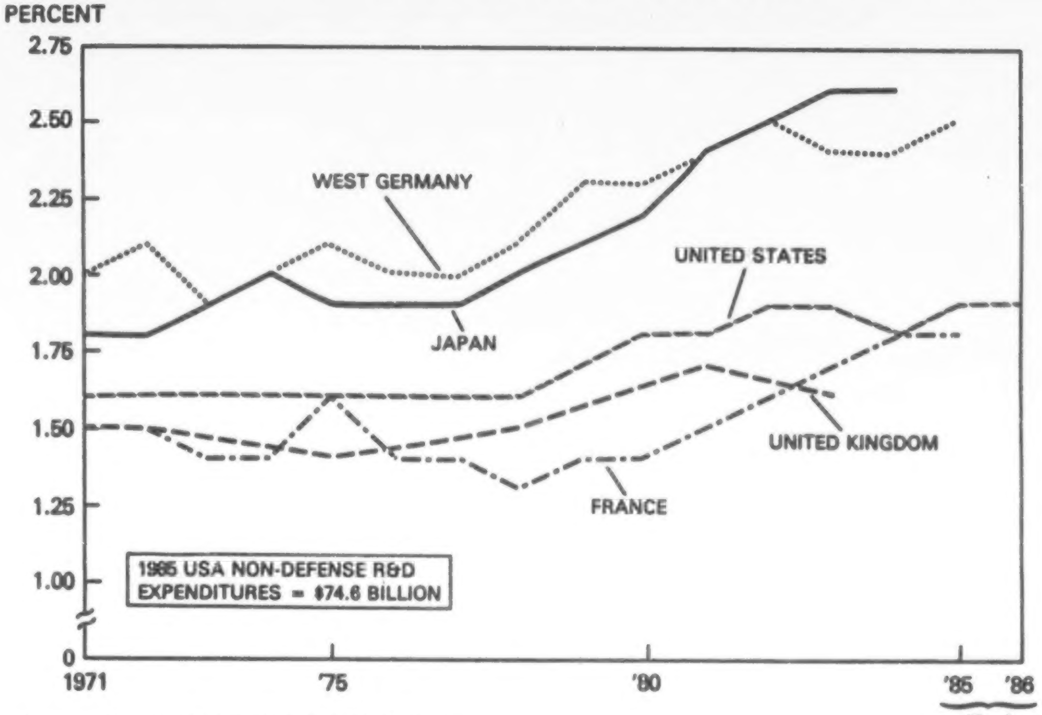


CHART 6

NON-DEFENSE R&D EXPENDITURES AS A PERCENT OF GROSS NATIONAL PRODUCT (GNP) BY COUNTRY



SOURCE: DIVISION OF SCIENCE RESOURCES STUDIES.

39-11/86

CHART 7

NATIONAL SCIENCE FOUNDATION
SCIENCE AND ENGINEERING EDUCATION DIRECTORATE OBLIGATION TRENDS

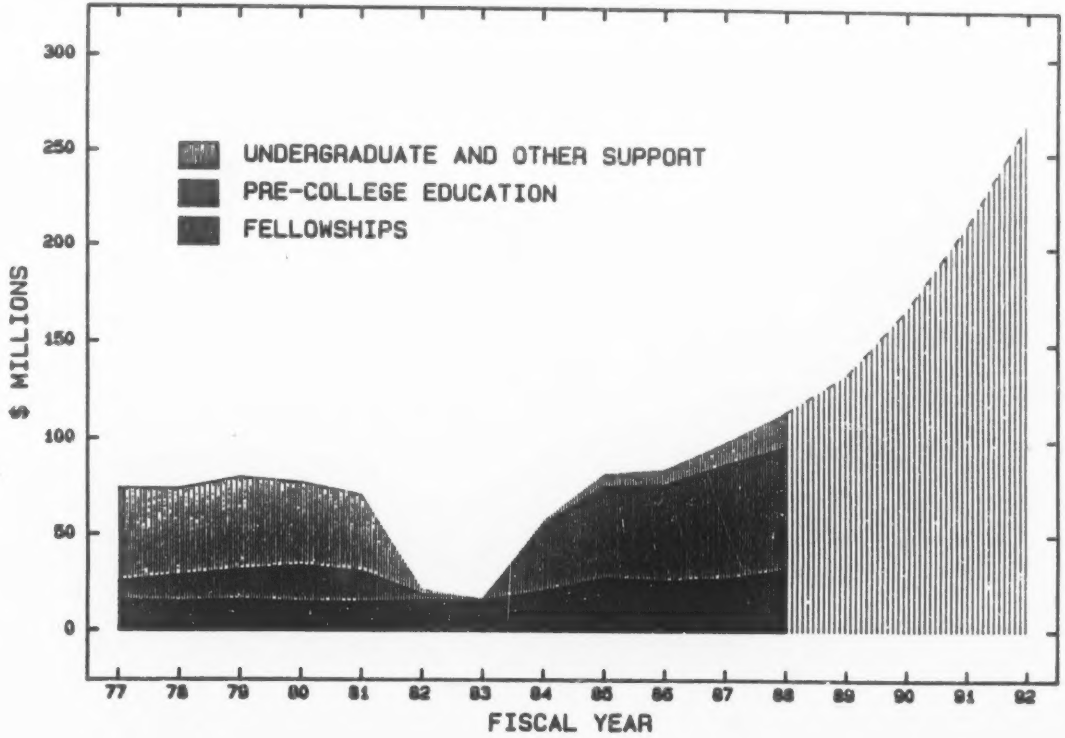
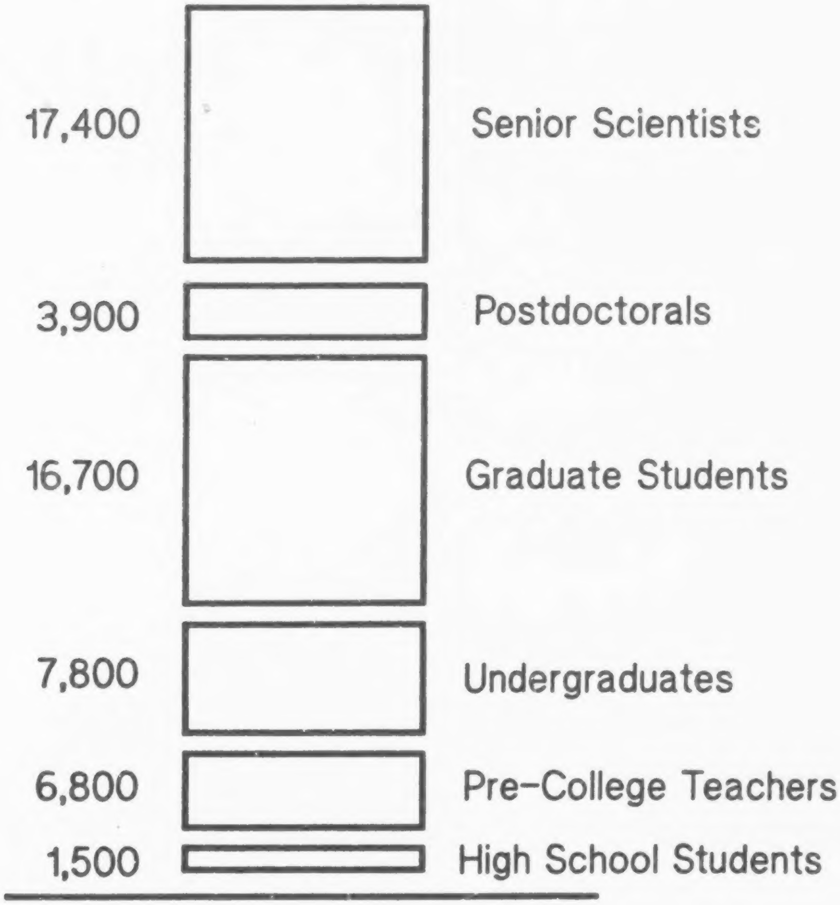


CHART 8

National Science Foundation Support for Human Resources in Science and Engineering

Fiscal Year 1988



Mr. **Walgren**. Well thank you, Mr. Bloch, for that statement. You really are going in many of the directions that we applaud, and I think in particular in the emphasis on science education it was with dismay that this Committee saw what happened in 1980, 1981, and 1982. And certainly we appreciate the recognition that the Foundation has given this area under your leadership, and we give great credit to that. But we will come back to that and try to give you a chance to explore it with us a little bit more in detail.

Let me ask at the outset what the Foundation's initial budget request at OMB was compared to what you got.

Mr. **Bloch**. Well obviously, it was higher than what we got. We asked for a 33 percent increase and a doubling over three years. We had many conversations obviously, and we wound up where we are today, which I consider, in light of—and you said it yourself—in light of the environment, a very good place to wind up at. But we certainly started with a higher increase for this year and also a faster doubling of the Foundation's budget.

Mr. **Walgren**. Well, we would appreciate it if you could submit that to us for the record, because in many ways, I hope that this Committee will be able to take an approach to the authorization that gives great weight to what we should be investing in this area. And in that light, it becomes very relevant to us what the exact breakout and the overall levels that someone in your position would be recommending for the national interest. So if you could submit that to us, we would appreciate having that to work from.

Mr. **Bloch**. Okay.

[Information to be furnished follows:]

NATIONAL SCIENCE FOUNDATION COMPARISON OF OMB REQUEST TO THE CONGRESSIONAL REQUEST

[Dollars in thousands]

	Fiscal year 1988 request to—		Difference Cong/OMB
	OMB	Congress	
Mathematical and physical science:			
Mathematical Sciences	$91,900	$67,800	(24,100)
Astronomical Sciences	107,200	92,560	(14,640)
Physics	160,600	131,330	(29,270)
Chemistry	132,600	102,750	(29,850)
Materials Research	146,200	119,560	(26,640)
Total MPS	638,500	514,000	(124,500)
Engineering:			
Chemical, Biochemical, and Thermal Engineering	38,200	31,483	(6,717)
Mechanics, Structures and Materials Engineering	36,050	28,520	(7,530)
Electrical, Communications and Systems Engineering	31,580	28,400	(3,180)
Design, Manufacturing and Computer-Integrated Engineering	21,450	17,970	(3,480)
Emerging Engineering Technologies	0	19,380	19,380
Critical Engineering Systems	74,880	27,747	(47,133)
Cross-Disciplinary Research	66,840	51,500	(15,340)
Total Engineering	269,000	205,000	(64,000)
Biological, behavioral and social sciences:			
Molecular Biosciences	89,900	73,751	(16,149)
Cellular Biosciences	75,970	60,589	(15,381)
Biotic Systems and Resources	88,490	72,810	(15,680)
Behavioral and Neural Sciences	66,150	53,816	(12,334)
Social and Economic Science	41,820	36,034	(5,786)

NATIONAL SCIENCE FOUNDATION COMPARISON OF OMB REQUEST TO THE CONGRESSIONAL REQUEST—Continued

[Dollars in thousands]

	Fiscal year 1988 request to—		Difference Cong/OMB
	OMB	Congress	
Total Biological, Behavioral and Social Sciences	362,330	297,000	(65,330)
Geosciences			
Atmospheric Sciences	126,850	106,700	(20,150)
Earth Sciences	80,740	63,350	(17,390)
Ocean Sciences	174,370	149,450	(24,920)
Arctic Research Program	12,040	10,500	(1,540)
Total Geosciences	394,000	330,000	(64,000)
Computer and information science and engineering:			
Computer and Computation Research	57,600	43,351	(14,249)
Information Robotics and Intelligent Systems	26,400	19,870	(6,530)
Microelectronic Information Processing Systems	24,200	18,214	(5,986)
Advanced Scientific Computing	81,800	48,200	(33,600)
Networking and Communications Research and Infrastructure	0	13,365	13,365
Total CISE	190,000	143,000	(47,000)
Scientific, Technological and International Affairs:			
Industrial Science and Technological Innovation	24,370	19,413	(4,957)
International Cooperative Scientific Activities	15,190	11,964	(3,226)
Policy Research and Analysis	2,070	2,000	(70)
Science Resources Studies	7,420	5,233	(2,187)
Research Initiation and Improvement	15,450	12,390	(3,060)
Total Scientific, Technological and International Affairs	64,500	51,000	(13,500)
Program Development and Management	93,920	95,000	1,080
Total Research and Related Activities	2,012,250	1,635,000	(377,250)
U.S. Antarctic program:			
U.S. Antarctic Research Program	$13,000	$13,500	$500
Operations Support	117,000	129,500	12,500
Total, U.S. Antarctic Program	130,000	143,000	13,000
Science and Engineering Education:			
Teacher Preparation and Enhancement	35,000	36,000	1,000
Materials Development, Research, and Informal Science Education	34,000	0	(34,000)
Materials Development and Informal Science Education	0	26,000	26,000
College Science Instrumentation	21,500	9,500	(12,000)
Research Career Development	38,300	36,000	(2,300)
Studies and Program Assessment	4,200	0	(4,200)
Research, Studies and Program Assessment	0	7,500	7,500
Total, SEE	133,000	115,000	(18,000)
Special foreign currency: Research and related activities	0	0	0
Total National Science Foundation	2,275,250	1,893,000	(382,250)

Mr. **Walgren**. The concept of doubling as accepted by the Administration, and doubling over three years as you internally recommended to the Administration, is something that I hope we can appreciate the importance of. There have been—it has often times been said that we need to take a longer view in the Congress, and one of our problems becomes one of detail in the outyears, and at this point we don't have very much detail when you ask for a long-term authorization.

Can you provide us greater detail for the outyears?

Mr. **Bloch**. Well, let me tell you what we are doing in that regard, right now, with the commitment of the Administration to a doubling over five years. We have started a series of planning groups within the Foundation that are essentially trying to outline in fair detail, not in total detail—obviously, you can't, especially as you go out to the fourth and fifth year—but in fair detail and at least in a strategic sense, what our approach would be, where the areas of focus would be, general areas of focus would be, and how we would see the Foundation moving forward in that regard. And this is going on right now and it's going to be reviewed in June by the National Science Board, getting their input into it and their views and policies into it, in order to be ready for submission back to OMB at the end of August or beginning of September when we have to submit our 1989 plan. Rather than submitting only a 1989 plan, we really want to submit a five-year plan to OMB.

So if you ask me today, can we supply you with the details, no, we cannot. We have to essentially focus in fair detail on the various areas. The approach that we are taking—and I need to say that here—is similar to what you have seen in the 1988 budget. It essentially looks at the three major areas: Education and Human Resources, Science and Technology Centers or centers and groups specifically, and individual-investigator grants or disciplinary grants as the third item, and it is time to track that over the next five years.

Mr. **Walgren**. Can you give us any idea what the Foundation should look like five years from now? I think one of the most interesting things in your statement was that you mentioned that we have often attributed our difficulties to forces that are beyond our control. And one of the most interesting things about science and the role that science can play in the future is that if we invest in it properly it becomes within our control.

And politically, it's easier to blame shortfalls and pain on something that is external and not within our control. It's tougher to take responsibility for it and to make or take the actions ourselves that would improve our situation. But along that line, to do that we really need to know what the Foundation should look like in 1992.

And it's interesting to me to think that if you felt that there should be a doubling over three years, that then in five years or five and-a-half years I would think, given what we know of the role of science and technology in the future and the base from which we're starting which is quite small, we would be looking at doubling again within, let's say, six years if we followed your internal recommendations to the Administration.

Mr. **Bloch**. I wouldn't argue with those numbers at all. Quite to the contrary. I think what you can say is, what the Foundation should look like in five years from now, I think we should have solved—or if not solved, at least addressed the problems to a point where they look more within grasp of solving in a number of areas.

The first one is the infrastructure. And by infrastructure I mean people, and I mean especially instrumentation and capabilities in universities. I think that five years from now we should have gotten out of where we are today where we can see in front of us a lack of human resources because of a declining 22-year-old population. We can't do much about that, that's a fact. But attracting more people into science and engineering and preparing people so that if they are attracted they can then go into science and engineering. And that means pre-college education obviously. So I think we should have addressed that problem in a significant way.

Also the fact that our Ph.D. population is dropping on us in absolute numbers, we should have addressed that. The big openings, the large openings that exist today in colleges and universities in terms of faculty, we should have solved that problem, or at least be on the road to solving that problem. We have made starts in that, by the way. So that's one thing, infrastructure.

Instrumentation in universities, a very big problem three or four years ago, is still a problem today. It should be less of a problem then. We'll never—we'll always be somewhat behind, but I think today we are behind by too much. So that's one aspect.

I think we should have taken advantage of the ferment that is going on in all of the sciences, and especially in some of the emerging areas like biotechnology as an example, computer science, and so forth, and made sure that we bring these areas along, that we bring them to fruition, and that the results of that flow into industry. We should have solved, five years from now, or achieved a much closer coupling between industry and universities, which is very, very important.

And last but not least, we should have brought our basic sciences along to the point where they give us, where they have a critical mass level that is sufficient in order to support not only the civilian sector, but also defense and so forth. Today we are deficient in many of these disciplinary areas. Mathematics, for instance as an example, we have neglected over the years. We tried to rectify it over the last two or three years. We have some ways to go. But there are other areas, other disciplinary areas where we can make progress.

Last but not least, I hope that we have gotten to the point where we have a very good balance between the various ways of doing research. The Centers and the individual investigator awards, should be in better balance than they are today. We're catching up with Center activities. Obviously as I said before, the balance between those is very important, and I hope that in five years we will have gotten to a point where everybody can agree the balance is right, and a new kind of an approach to the way of doing research has been introduced and accepted by the universities.

Mr. **Walgren**. But the way I read that is that there are some severe present deficiencies that we are essentially fire-fighting.

Mr. **Bloch**. That's right.

Mr. **Walgren**. But would I be wrong in—and not putting words in your mouth—that it is in the nature of science and technology that after we put out these fires and we strengthen these areas and perhaps strike a better balance, it is in the nature of what we do in science and technology that the investments should be—certainly are not going to be properly decreasing. And in fact six years out, seven years out, eight years out there will be new instrumentation at that point that will be required. And it's the nature of the investment in science and technology that we should anticipate increasing roles here.

Mr. BLOCH. Absolutely. I don't think we'll ever be done with that particular job. But I believe that the big deficiencies that we see today and the problems that we see today in universities and colleges in research and education and so forth, that we can diminish those problems and resolve many of these problems, so that we have more of a—so that we are no longer in as much of a catch-up mode as we are today.

Miss SCHNEIDER. Would the chairman yield for just a moment?

Mr. WALGREN. Be happy to yield.

Miss SCHNEIDER. One of the things that concerns me is that you're saying that we should not be in that position in the future. But yet as we look closely at this particular budget, I note that one NSF activity that does not receive an increase is the whole area of university equipment. That level is frozen; is it not?

Mr. BLOCH. No.

Miss SCHNEIDER. At the '87 level.

Mr. BLOCH. No, that is not correct. In fact, Miss. Schneider, that particular area of equipment as you call it—it's instrumentation and equipment. It's both. It has been getting a lot of emphasis over the last three years. You're not seeing it necessarily broken out on a line item by line item basis. You really have to make a cross-cut of it, which we have supplied to this Committee over the last couple of years.

But for instance, today we are spending close to, I'll say, 18 percent of our total budget goes to instrumentation.

Miss SCHNEIDER. How does that break down in terms of dollars, approximately?

Mr. BLOCH. In terms of dollars, that's what I'm talking about. So we are spending more money on instrumentation than we ever have done before. Are we spending enough? And that was the point I made before. No, we're not.

Miss SCHNEIDER. What I'm looking at is the Packard-Bromley report which calls for approximately $10 billion in order to adequately address the academic facilities programs.

Mr. BLOCH. Let me take instrumentation for a minute and then come back, between instrumentation and equipment and brick and mortar facilities. I think the Packard-Bromley report, I think talked about both, but in particular about brick and mortar.

We are spending, by the way, the Foundation is spending about $50 to $55 million in facilities money, special research facilities money. I want to underline that. In fact, we are probably—not only probably—we are, of all the Agencies, spending more percentage-wise, higher percentage on this area than the rest. We are spending about 55 percent of what the government spends in this area.

Miss SCHNEIDER. Is this including undergraduate colleges also?

Mr. BLOCH. We have one particular program that addresses instrumentation for undergraduate laboratories, which is the CSIP (College Science Instrumentation Program) program in particular.

Miss SCHNEIDER. And that's the one that's frozen?

Mr. BLOCH. No, it is not frozen. It has a $9 million kind of a target in '88. But in addition to that, there is money in the individual directorates that is applied to this particular program. So in total, there's roughly $20 million that we have in the budget for it.

The reason why you don't see everything in the SEE Directorate in this particular area is because there are requirements that disciplines specifically have, and we want the disciplinary divisions and directorates to handle that part of the program. But it's not frozen in 1988. In fact, it's increasing.

Miss SCHNEIDER. Good. Thank you, Mr. Chairman.

Mr. WALGREN. The chair recognizes Mr. Boehlert.

Mr. BOEHLERT. Thank you, Mr. Chairman. Mr. Bloch, I want to commend you for your testimony. And I want to start initially by making reference to a statement on page 2 which says—and you don't have to bother referring to it because I'll amplify my comments. But this is a direct quote from your testimony. It says, "Seeking productivity through research and technological innovation is the way we should enhance our position in international and economic competitiveness. It is far preferable to reliance on trade barriers or other protectionist measures."

I want to underscore that statement and tell you how much I agree with it. On Capitol Hill, Administration bashing is one of the more popular sports every time a budget is submitted. And we hear such phrases as "dead on arrival" and that sort of thing. And it doesn't seem to make much difference who is in the Oval Office or what the numbers are up here on the Hill. There's a tendency just to say, "we've got to work our way and we've got to do everything differently".

In this instance, I think the Administration deserves outstanding marks for the submission of your budget to us, because they are doing what I think we recognize has to be done. This Administration—and I'm not here to be a cheerleader, but I want to give it credit. The supercomputer initiative was launched in this Administration. The Engineering Research Center Program has been launched. The commitment to the National Science Foundation, not just for this year, but longer range, is solid and I applaud that.

I also want to make reference to another statement of yours, and you say, "The creation of a scientist or engineer takes many years. The process begins in the pre-college years and continues through undergraduate and graduate training." Given that, and I agree with it, I have a few questions.

One: You recently announced the creation of an Office of Undergraduate Education in the Education Directorate. Can you give us an idea of what the responsibilities will be and how much control, if any, it will have over the Research Directorate and how the research directorates spend their undergraduate money?

Mr. BLOCH. Yes, I'll be glad to do that. By the way, obviously I agree with your comments on the Administration's budget request. And let me just remind you that in the 1986 and 1987 budgets that were sent up here, the National Science Foundation was in for bigger increases than Congress finally wound up with, and that was submitted by the same Administration.

Let me talk about the Undergraduate Education Office. Like many other—and I will give you some examples—like many other programs in the Foundation, this particular program of undergraduate education has to do with equipment, as we just discussed, in laboratories. It has to do with high school students, getting them into a research environment during a summer or what have you. It has to do with faculty training for undergraduate teaching. And it has to do with new curriculum development in areas that are very important and where the curriculum has been left behind by the progress of research in science and engineering.

These areas are essentially, then, the responsibility of the individual directorates to fund those areas. But in order to make that happen, and in order to keep a good check on it, and in order to make sure that all of these individual programs make a coherent whole and that we're not leaving out—we're not leaving holes behind or areas untouched, we need to overview them on a daily kind of a basis.

So it will be the function of this Undergraduate Office to have at all times a strategic plan in place against which they can monitor the day to day activities. That's point number one.

Second one: As we go out for solicitation for these things we make sure that the solicitation across the Foundation is consistent, not that one directorate has one set of criteria and the other one has another set of criteria that are completely opposed to each other.

Mr. Boehlert. What kind of staff is it going to have?

Mr. Bloch. I like to work with a lean staff. I hope that two or three people can do that particular job.

Mr. Boehlert. What kind of input is it going to have though on how the other directorates spend their undergraduate money?

Mr. Bloch. It will have everything available, the original budget, the monthly outlays that occur, the detailed programs and/or projects that are being undertaken. So everything like that is available to them.

In addition to that, it should be a focal point for the community on the outside, so that people can come in that are interested in undergraduate education and don't have to go to 20 different divisions or program offices, but can go to this one particular office and then that office can get them the answer, or the advice, or the guidance that they need and that they are asking for. It's both an internal and an external type of a function.

Mr. Boehlert. I understand you just had a report presented evaluating your NSF programs and the needs of the middle schools. Can you talk about that report a little bit?

Mr. Bloch. I don't know what you're referring to.

Mr. Boehlert. It was a management study. Your basic premise, I think is so accurate. We can't produce a scientist or an engineer overnight. And we can't start at the graduate level, although it's important to support graduate programs or even undergraduate. You've got to start at the beginning. And I want to know what you're doing and how you're doing it.

Mr. Bloch. What you're referring to in all probability is the evaluation program that we have in place where we essentially hired two contractors. One, Triangle Institute and the other one, SRI. I've heard a verbal report, but I've not seen the final report yet. They're in the process of developing the final report.

But that essentially was done for the purpose, to find out early in the game and continually, not just once, how well our pre-college education programs are fairing, number one. Again, what should the strategy be there? What are we doing and what we are not doing. Do we have the priorities? Do we have evaluation criteria in place? It is very important, that we not just spend money without knowing what the return has been.

Mr. BOEHLERT. How well are we doing?

Mr. BLOCH. I would say it's too early to say. As you said yourself, or as the Chairman said, 1981 was really—saw the dissolution of the whole directorate, and we have been building it up just over the last three years. And it has been built up very gradually but very solidly, and I think we have to see the results. We can tell you numbers of people that we are touching. But I would say from a qualitative viewpoint, what changes have you brought about and how well have these changes changed the environment? I think it's too early to say, but that's what we're laying in place to make that determination.

Mr. BOEHLERT. I want to switch gears for a minute. A couple of quick questions on one of my favorite areas, the supercomputer initiative. Then I'll yield to other colleagues and we'll get to some additional questions I have.

How much money do you need to fulfill the original commitment to the supercomputer centers?

Mr. BLOCH. I don't know what you mean by the original commitment. Let me try to review the situation. When we first started off in '84 and '85 in particular, the question was asked, "How many centers do you need?" And I think we answered at that time something like 10 or 12 centers.

In the meantime, we have established five centers. And we have done that very deliberately, establishing these five centers and stopping at that particular point. Now why did we stop? For two reasons.

First of all, in the meantime—and I would say because of the initiative of the National Science Foundation putting the focus on this particular problem—other agencies, and in particular the universities themselves, together with the states and the manufacturers have established other computer centers, supercomputer centers, to the point where I'm convinced that while we never will have enough supercomputer centers available, what we have is probably sufficient right now, in light of the fact that we really need to address other problems that are related to supercomputers.

And that other problem I'm talking about is the networking, the access to the supercomputers, so that you can be anywhere in the United States in any university, on any college campus, and you want to have access to Cornell or you want to have access to San Diego or you want to have——

Mr. BOEHLERT. I know about the networking and how important it is. But when you established the five centers—I mean, I think there was a basic commitment for a certain amount of dollars from NSF. Could you review where we are with respect to that commitment? I mean, there's some concern that maybe we're not living up to our end of the bargain.

Mr. BLOCH. Let me tell you where I think we stand on that one. A lot of things have changed also. Some schedules have slipped. For instance, we are waiting for a new machine from ETA-10. We took some money out of Princeton, no doubt about it. Princeton is getting less money in 1987 than what we had planned on spending in Princeton in 1987, no doubt about it.

They got less money in 1986, but I think that was justified, because I don't know where the money would have been spent. The machine was delayed. In the meantime, we got commitments out of the manufacturer to give us some free time on other machines and so forth, so I think we have saved the taxpayers some money by taking money out of there.

We have plans in all centers to upgrade the machines. The machines have to be upgraded. I would think that we are going to do that. Certainly we might not do it exactly on the time scale that some center managers would like us to do it. I would say right now we are probably $5, $6 million short if you wanted to do it in a quick kind of a way. And we had to make a compromise in that particular regard.

Mr. **Boehlert**. But I can understand, Mr. Bloch, I can understand the problems with the Princeton center. But if I were to write to the other four centers and ask what they view as the original commitment and do they feel that NSF is living up to that original commitment in terms of funding, what would be my likely response?

Mr. **Bloch**. Your likely response would be a mix of answers saying we have not quite lived up to our commitment and that they would like—that they could use more money to do other things, other things related.

Mr. **Boehlert**. Yes, but my point is, everyone would say they could use more money. But I'm talking about commitment now. That's an important word to me and I know it is to you.

Mr. **Bloch**. Right. I would say that you, probably right now, would get the answer that we are short about $5 million in total, and that's probably what we are short. But on the other hand, I would say, yes, that's probably right. But looking at the balance of things, we have no—first we have no choice. And secondly, I think it's very important that we push the other areas along also.

So we're certainly not up to our commitment level, but we are not that far behind.

Mr. **Boehlert**. I don't want to—I do want to monopolize it, but I won't. Mr. Chairman, I'll yield back.

Mr. **Valentine**. Mr. Bloch, the NSF budget request proposes, and I'm quoting, "Establishing Science and Technology Centers in all disciplines because of the key role such university-based centers can have in stimulating economic competitiveness."

My question is, what criteria would be used, would you use to evaluate the center's contribution to economic competitiveness?

Mr. **Bloch**. That's a very good question, and obviously we have asked ourselves that question over and over again. In fact, we are in the process of setting up evaluation criteria for the first six Engineering Research Centers that have now been in existence for three years. And we said in the beginning we would evaluate them in three years.

And the criteria, there is not one bottom number that you can look at and say "good or bad". You have to look at a number of parameters. The ones that I put very high marks on are the following:

First of all, how many undergraduate and graduate students got their education in that particular center, or participated in that center's activity? A very important point because one component is education. Not just research, education.

The second one is, obviously, what have the research results been in terms of the papers, the quality of the papers, and the patents that came out of there? And that applies to Engineering Centers more than, obviously, to Science Centers. So that's the second criteria.

The third one is, what did the center do to improve the atmosphere in the university? And by that one, I mean the educational atmosphere in the university. How much did they contribute to graduate education in terms of not only the experimentation, but also curriculum development that came out of the center itself? That's the third criteria.

Another one, obviously very important, is, what does industry think about these centers? And you can see that best by essentially asking the question, does industry participate? How does industry participate? Not only the dollars that they are putting in, but the people that they are putting in. And what have they gotten out of it essentially? A very important criteria.

Last but not least, obviously, the question; what have the centers done to the university itself? How many extra faculty positions have been created because of the centers? And have we enlarged essentially the competence of that particular university and the capabilities of that university? Also how much access through the center, and to new instrumentation, not only to the center members and people that work in the center, but to the rest of that particular community?

So those are about—its knowledge generation, its industry participation and technology transfer, and it is education. Those are about the parameters we are looking at.

Mr. Valentine. In view of the proposal to double the NSF budget in five years, can you tell us what growth in numbers and in dollars you project for these Science and Technology Centers in that five year period?

Mr. Bloch. As you know very well, as one establishes centers of this sort, the cost of the centers over time increases, obviously, because you start them small, and they grow and what have you. So the first thing that I want to essentially say is that in 1988, we are seeking about a 48 percent increase in the center budget.

And I would think—and that would allow us to establish maybe 15 or so new centers including Engineering Centers as well as Science and Technology Centers. And by the way, we are focusing very heavily obviously on the Science Centers themselves, and then over the years will increase those. I wouldn't be surprised if we had something like 70, 80 new centers in three to five years.

Mr. Valentine. These centers have been established to help forge, as we've seen closer ties between university researchers and industrial needs. Now is there, in your opinion, an irreconcilable tension between the notion that centers engage in basic research, but be concerned also with industrial problems?

Mr. BLOCH. No, I don't think there is an irreconcilable difference. Let me say what the centers are charged with. The centers are charged with basic research, be that in the engineering disciplines in which the centers exist or in the science areas in which the centers exist. Industry needs basic research because that's how you—on that you build your product line eventually.

So industry should understand that they cannot look to these centers as a generator of new products in a direct way, only in an indirect way. Industry also has to understand that it depends very heavily on the education that goes on in universities. That's where it hires its people from.

So if these students, graduate students or undergraduate students, or high school students for that matter, that are involved in center work, they have a better appreciation of what research is all about, are better prepared to go into industry, and that's of a direct benefit to industry. So if industry realizes the place of the university, vis-a-vis its own place in life, I don't think these differences are irreconcilable.

What you sometimes see is that there is a tendency by one side or the other to play a role reversal game and that gets us into difficulties.

Mr. VALENTINE. How likely is it, in your opinion, that these ERCs (Engineering Research Centers) will become really short term problem solvers?

Mr. BLOCH. That depends on the management of the ERCs and the oversight that we are giving them. And I think we can prevent that from happening.

Mr. VALENTINE. To what extent, Mr. Bloch, does NSF target support for centers that have particular relevance to specific industries judged either to require special help or to have a special promise for growth?

Mr. BLOCH. Let me tell you how we operate, and then I can reflect a little bit on the long term aspects.

The way we have been operating so far with the Engineering Research Centers, and we're going to do the same or a similar kind of an approach with the Science Centers; we went out with a general solicitation that spelled out the general framework for centers. We did not target any particular discipline or any particular problem area or any particular industrial kind of a relationship.

What we got back from the universities—and one of the stipulations was, you have to work with industry for this center to be effective. And that was one of the prerequisites for coming back in and showing us how that working relationship, what that working relationship would be.

What we got back from the universities were a large number of areas, problem areas, disciplinary areas, interdisciplinary areas that they had worked out with their counterparts in industry, and in the states, and in the universities themselves. Out of that one, we chose those that we would fund, which is a small portion of the total.

So it's not that we set criteria. Essentially you've got to work in area X, or in area Y, and area Z is out of the question. We didn't do that.

We have now 11 centers established, Engineering Research Centers established. We're going to establish another three in the next few weeks, a couple weeks or so. We are going to go for another round in 1988. We have been thinking of looking at some very generic kind of areas.

Should we specify—not specify, but should we focus on a few areas so that centers know or some of the candidates know what areas are not covered today? We might do that. But we have not done that so far. We would do a similar thing in the Science Centers.

Mr. VALENTINE. One final question, Mr. Bloch. To the extent that you haven't already answered this question, tell us what criteria would be used to evaluate the effectiveness of these centers?

Mr. BLOCH. I mentioned before what the parameters are that we are looking at, education components, research output and industrial participation. Those are the three major areas that we are going to evaluate the centers by.

Mr. BOEHLERT. Before you yield, Mr. Chairman, to Miss Schneider, may I ask a question as long as we are on ERCs? Some of the outside witnesses have said we should honor the five-year commitment for the funding for the ERCs and not go one day beyond that, fearing that we're going to get into the sort of pork barrel politics we are infamous for up here on Capitol Hill. What is your view on that? Should it be five years and that's it, and then go on to some other centers? Or if you look at some of these centers and you see maybe a little stretch-out? Just address that.

Mr. BLOCH. Well, let me give you my view on it. By the way,—well, I will make the comment later.

No, I don't think five years is the right time length. I think first of all, it depends on how well the centers are doing. We should evaluate and we are evaluating them after three years with the idea that the centers that are not performing well, by the standards that I just mentioned, will be phased out after five years. Very clearly. But I don't think we should have that rule for everybody, especially not for the centers that are doing very well and that have a plan in place that is very well thought through, very important for the future. And I think we should go with those centers the second round.

Right now, the way we are thinking about it, and it is not firm, I want to underline that, is that after three years we are going to evaluate the centers. Those that are doing very, very well we are going to give a five-year extension that would bring them up to year eight. And then at year six, two years before the year eight, evaluate them again. If they are again doing very well, give them another five-year, a last five-year extension, which would get them to a maximum of 11 years. A maximum of 11 years.

But you have the capability of dropping them off at year three, with a two-year kind of phase-out, so to year five and that's the end. You can drop them out at year six with the two-year phase-out and that would be an eight-year kind of a program. Or they can go all the way to an 11-year program. But I think five years is too short a period of time.

If we are selecting the topics correctly, and let me give you a couple of examples. Telecommunications. You know, the telecommunications area is a booming area, it's an emerging area, it changes daily. I have no reason to believe that it will have reached a stable state in five years from now. It probably won't have reached a stable state in 11 years, either, that's true, but 11 years is better than five years.

Robotics, the whole area of robotics. We are just starting pretty much at a very low level, and it will develop very considerably. Many of the materials areas have a gestation time that is certainly longer than five years. Composites—we won't be done with composites. We will be lucky if we see the first usage of composites in a grand way five years from now.

Mr. BOEHLERT. I guess, Mr. Bloch, the concern is that political judgments will override professional judgments, and I am a believer in peer review and I'm a believer in you guys, you people at NSF, making the decisions rather than power politics on Capitol Hill dictating where an Engineering Research Center is going to go or something of that nature.

Miss Schneider I know is getting ready to ask questions, she has been very patient, but I did want to get that on the record.

Mr. WALGREN. The Chair recognizes the gentlewoman from Rhode Island.

Miss SCHNEIDER. Thank you. Mr. Bloch, I would like to say that I am most impressed with your administration of NSF and the way you think and your efforts in trying to not only increase the budgets but make sure that those budgets are effectively used. And oftentimes, we are not overly enthusiastic with our compliments, but I think it is only appropriate that someone who has left the private sector—we know that you are really doing public service work here and we know that it's a tough job, and I just wanted to commend you.

Now on to the tough part.

Mr. BLOCH. I thought you were done. [Laughter.]

Miss SCHNEIDER. No, see, I have a different style. I usually wear white gloves but I carry a club behind me.

I am quite sure that you are aware of what the future labor pool of the United States looks like, the increasing number of women that are entering the labor pool, the increasing number of ethnics and minorities; the greying of America is a factor that needs to be pounded in in any equation as you are looking toward the future, and the shrinking number of young people. Not to mention the group of people that are characterized as "at-risk youth" who are children who are perhaps born of teenage parents or who have limited proficiency in the English language or who are disadvantaged economically in one way or another.

What concerns me is, seeing as how this is essentially the raw material that we must deal with, and looking at the vision and our goal as to where we must go as a nation in terms of building a high-flex society that is technologically competent and proficient, what is the route that you are devising between the raw materials and the final competitive edge that we hope to achieve in addressing those women, minorities, aging, limited young people, *et cetera*, and getting them scientifically turned on and proficient?

Mr. BLOCH. Well, that is quite a question, and let me try to answer it, and I will ask John Moore to add to it.

First of all, we have some regular programs in the Foundation, or in fact, all programs in the Foundation obviously are open to everybody, so that is certainly one area. And that applies to research and it applies to education as well.

But then we have some special programs which we have devised over time and added to over time to address the problem of underrepresentation, especially minorities and women. And those programs are again in the research area as well as in the undergraduate education area, as well as in the pre-college, somewhat in the pre-college area.

So we are essentially not just depending on the normal mode of operation of the Foundation to attract people from the under-represented groups, but we are making a very special effort in this area. Sometimes we go out on an individual basis; for example, Visiting Professorships for Women obviously addresses a particular individual, they don't address an institution. But then many times we are going out there also and addressing the whole institution essentially.

The Minority Research Centers of Excellence—that is a new program in 1988—is one of those efforts at establishing—I'm sorry, in 1987 and continuing obviously intc 1988—at establishing centers of excellence in minority institutions that will reach out and involve and upgrade the institution, and involve both undergraduates, graduates and even high school students around it.

Miss SCHNEIDER. Have the solicitations for that been made yet?

Mr. BLOCH. Solicitation has been made for that. It comes in two parts. You can either bring in a proposal that proposes the establishment of a center, or you can ask for a planning grant so that next year you can present a proposal. Many of these institutions need that planning time and that planning grant in order to put their institution's best foot forward, essentially, and understand how they would attack a problem of this sort. So they can come in either way.

We have planned on five or six of these centers by next year. We have planned on something like 10 to 15 grants this year for planning purposes. I don't know what the result will be as it finally comes in.

Miss SCHNEIDER. So you are targeting black colleges, in essence.

Mr. BLOCH. Right.

Miss SCHNEIDER. And women's colleges also?

Mr. BLOCH. No. This one that I was talking about was a Minority Center of Excellence Program which targets primarily black colleges.

Miss SCHNEIDER. Okay. But we don't have anything that targets women's colleges?

Mr. BLOCH. There is no equivalent of that one that targets women's colleges, that is correct.

Miss SCHNEIDER. Well, I am aware that there has been a task force that is charged with Women, Minorities and the Handicapped in Science and Technology. Of course, OSTP, Mr. Graham, is to convene the first meeting which was supposed to have taken place last November. It is my understanding now that you are just gearing up to get going. I hope that you can provide some of that forceful leadership in that task force that we have seen you provide within your own Agency. But I think we had better hurry up on that front.

Mr. **Bloch**. Can I comment on that point?

Miss **Schneider**. Yes.

Mr. **Bloch**. That committee that you are talking about is indeed being put in place. We, like all the other Agencies, are participating in it. We have two representatives on it. There are representatives on it from the private sector also, as well as from universities. It is a congressionally mandated, as you know, committee. It is really patterned after one that we have had in existence inside the Foundation for three years, I guess. Four years. So it is patterned after that. We have that committee operating within the Foundation; they have looked at all of our programs and they are helping to formulate the programs. I look at them as part of the Foundation's effort, essentially. It has worked very well there; I suspect it will work very well on the national level.

Miss **Schneider**. Okay, thank you. I was just looking at a recent NSF study that found that 20 percent of the universities' scientific equipment is obsolete and no longer used. This is going back to the question that I had asked before. 72 percent of the department heads that were polled said that the lack of adequate equipment is preventing critical experiments. It is interesting to note that half of higher education's physical plant, being the research labs and equipment and libraries and classrooms, is more than 25 years old.

The estimated cost of replacing and renewing the physical plant is $30 to $40 billion. And given those statistics, the other information that I have learned is that the J.F.K. School of Government has also done a study where they polled 100 different companies that are involved in the biotechnology field, and those firms reported that university research results in two to four times as many patent applications as research from other sources, including their own corporate laboratories.

So I guess I'm a little hung up with these studies, with the Packard-Bromley report which calls for the expenditure of $10 billion, and this one suggesting that it would cost to replace and renew the physical plant $30 to $40 billion, and granted you said that the monies are in cross-cut disciplines, but you threw out the figure $55 million—I can't help but think that the kind of dollars that we are talking about, compared to what these studies are indicating the needs are, that NSF is essentially only going to be providing a drop in the bucket for those purposes. And I wonder if you could please help clarify for me or persuade me otherwise.

Mr. **Bloch**. I would like to ask Dr. Moore to answer that question.

Dr. **Moore**. I will make a few comments on it. First of all, as Mr. Bloch indicated earlier, within the general area of facilities, it is important to differentiate between general purpose facilities and specialized research facilities. And we have made it our policy to provide support for specialized research facilities where they are needed to carry out particular pieces of research that have been proposed for NSF support, and we continue to do that and we continue to put a fair amount of support into that particular purpose.

We have not made it our policy to try to provide support for general purpose scientific and engineering facilities, which often are called the bricks and mortar. And I believe it is in that connection that you get these figures of $30 to $40 billion.

The other side of it is the side of instrumentation and equipment, which is a little separate thing and I think what you were referring to at the beginning of your question. There I would again note Mr. Bloch's comment earlier that somewhere in the vicinity of 17 to 18 percent of our budget is now being spent on instrumentation for research purposes and other purposes. That comes, roughly speaking, to about $250 million per year, so we are making a very substantial investment.

I believe that it is true to say that we provide a larger percentage of our budget in this respect than any other science funding agency—that is, for instrumentation—and we have taken that as a very important priority within our budget.

Miss **Schneider**. Packard-Bromley also suggested shortening the depreciation schedules for buildings and equipment. Has there been any progress on that front?

Dr. **Moore**. Not to my knowledge. I do not think that the OMB circulars have been changed in that respect.

Miss **Schneider**. Anything that you can do about that?

Dr. **Moore**. We can encourage that, and we would like to——

Miss **Schneider**. Will you encourage that?

Dr. **Moore**. We have encouraged that.

Mr. **Bloch**. We have encouraged it. But let me spend one more minute on it and clarify a couple of things. Equipment, instrumentation, that part. We are spending $300 million in 1988 on that, which is not an insignificant part of the National Science Foundation's budget, as I know you realize. We are spending $50 million, roughly speaking, on facilities per se, and those are the facilities that Dr. Moore pointed out are specific ones that are important for the research.

Last year, we went out with a notice to all of our principal investigators in universities and said, if you have a requirement that links your research task with the need for facilities—in particular, upgrading of facilities—please come in, and we will consider it. So we are linking the two together and we are entertaining proposals, especially in the upgrading area of facilities, which is very important.

We just went out—and Congress has that particular report [1]—to all of the universities or a good sample of the research universities and asked them the question, how are you doing on brick and mortar facilities? And that report is in your hands. And it's very clear from that report that there is a problem, and it's the problem that you cited.

There is also a clear indication from that particular report that a lot of building is going on and maintenance improvements are going on, primarily funded through either the private or the state sector, not through the federal government. But it is not that there is no building going on out there. In fact, I was surprised how much building is going on.

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[1] Science and Engineering Research Facilities at Doctorate-Granting Institutions, National Science Foundation, September, 1986.

I need to say one thing on that. That the new tax bill doesn't help because it limits you.

Miss SCHNEIDER. Yes, I am aware.

Mr. BLOCH. I know you are well aware of it. So that might have a negative effect on a very important kind of a problem, and I just wanted to bring that to your attention.

Miss SCHNEIDER. Well, I think that—are you going to be meeting with the President sometime soon?

Mr. BLOCH. It's not on my calendar. [Laughter.]

Maybe it's on his.

Miss SCHNEIDER. Well, let me leave you with a special request that I think probably all of the members of this Committee share, and that is that it would certainly serve our country well if the great communicator were to get the bug in his ear that he should be communicating on the need to encourage our young people to pursue the areas of science, math and engineering, and what better person to deliver that message than yourself. Particularly if you were to tell him that between 1954 and 1968, that science and engineering and R&D at universities doubled, and graduate population during that time tripled. But since between 1968 and '74, there has been absolutely no growth whatsoever in the scientific and engineering community in terms of young people pursuing those areas of study.

Much of that had to do with Sputnik. I think there is very little question that we have a national challenge on our hands now in being economically competitive in the global economy. And here is an area where we can take the football game analogy and, you know, win if we have greater investments in science, research and technology. And we need the young people to get involved in that area.

Mr. BLOCH. Let me just say——

Miss SCHNEIDER. You want me to be your cheerleader, I know.

Mr. BLOCH. Yes, that also. That's not what I wanted to say. Let me just point out one thing. That the Trade, Employment and Productivity Act of 1987 and the President's message exactly makes this particular point—to focus on education; education in mathematics, science and computer literacy is a very important aspect. In fact, he charges the Department of Education and the National Science Foundation with making that happen. So your message has come through.

Miss SCHNEIDER. Well, we know that because we are implementing it, but the American people haven't gotten that message yet and I think there needs to be more of a campaign to communicate that to the grass roots.

Mr. BLOCH. Well, let me say one thing. The President has made the point, when he released this particular message to Congress, that he would campaign for that whole package over the next few months. And I think that is very good.

Mr. WALGREN. Next we will hear from Mr. Ritter.

Mr. RITTER. Thank you very much, Mr. Chairman, and thank you, Mr. Bloch.

I'd like to follow up on my good friend from Rhode Island's questions about science and math education.

Has NSF done any studies to try to analyze the reasons for the steep decline in both recruitment and retention of high-level people in science and mathematics? And as a corollary, are you familiar with the Carnegie Foundation's report on teaching which views some of the problems in recruitment and retention?

Mr. BLOCH. Well, I don't know what you mean by "study."

We have, as you know, in the science indicators, we display pretty much the quantitative aspects of that, how many people enter graduate schools, how many people enter undergraduate schools, in what fields and so forth.

With regard to a cause-and-effect relationship of that, no, we haven't—you know, we haven't done that.

Mr. RITTER. I would suggest—let's see, does your jurisdiction extend to science and math teaching in the secondary schools? I believe it does.

Mr. BLOCH. Sure.

Mr. RITTER. I would suggest that the NSF take a very close look at the—not just the indicators of falling mathematics and science recruitment and retention through the secondary schools, but also the reasons underlying what the problems might be.

I urge the Science Foundation to take a look at the Carnegie Foundation's report on the future of teaching, and they make some very, very significant points about the rewards structure for science and mathematics, and not just that, but highly professional skills in teaching as not being able to progress with respect to competition. It goes into depth and basically states that it's not so much a problem of starting salaries; it's not so much a problem of average salaries. It's a really severe problem of peak salaries, and it may have something to do with the complete lack of market sensitivity.

I think it's all well and good to pump money into a system, but unless we understand the root causes of why the system is dysfunctional, we're not going to be able to build the system tomorrow.

I am also concerned about——

Dr. MOORE. Mr. Ritter?

Mr. RITTER. Yes?

Dr. MOORE. If I may make just a comment, it's maybe a little—not the same level of education that you're talking about, but in our programs in research in teaching and learning, we do have some research in this area that is in progress.

Mr. RITTER. You do have a research project?

Dr. MOORE. Probably what we could do——

Mr. RITTER. If you could supply me with the research that you have that's ongoing in this problem area, I'd be real appreciative.

Dr. MOORE. Okay.

[Information to be furnished follows:]

ANALYSES OF THE FACTORS INFLUENCING HOW LONG MATH AND SCIENCE TEACHERS STAY IN TEACHING

The Office of Studies and Program Assessment is currently supporting research by Dr. Richard Murnane at Harvard University. This research will analyze the factors that influence how long math and science teachers stay in teaching. These factors include personal demographic characteristics, subject area specializations, salaries, and school district characteristics. The investigators will use methodologies, known as waiting time models, that have not been used previously in studying teachers' career paths. They will apply these powerful methodologies to three longitudinal data sets, from rich data on individual teachers in Colorado, Michigan, and North Carolina.

The research will emphasize *comparisons* between math and science teachers and other teachers, between teachers trained to teach particular sciences, between time periods (early 1970's versus early 1980's), and between regions of the country.

The results should be valuable for two reasons. First, they will inform policy discussions about how to increase the attractiveness of the teaching profession to college graduates with math and science trainings. Second, they should provide information useful to improving the teacher demand and supply models used to predict teacher shortages and surpluses.

Mr. RITTER. I have also a concern about the foreign graduate student percentages. It's really quite—it's another one of these problems where you could continue to put the money in there, but you don't get to the roots of why the foreign graduate student percentage is increasing and why we can't get the American students to go into these areas.

I'm concerned about, for example, in the Engineering Research Centers or in the Science and Technology Centers, I'm concerned about technology transfer and, again, the United States serving as a kind of sink for the basic science and the distribution being extraordinarily effective via the graduate students who study here and go back.

What percentage of the graduate student population presently is returning to their home countries?

Mr. BLOCH. Well, obviously that varies from discipline to discipline. But in the area that you are focusing on, in engineering, about 55 percent of the people stay here. So about 45 percent are going back for one reason or another.

Let me make two points on that, and not to minimize your concern, because I have talked about that subject myself and am very much concerned about it myself. There are a number of things that need to be said on it, however.

The first one is, yes, we are not attracting enough Americans into graduate schools, especially into the Ph.D. track, and I think there are a number of reasons for that. The first reason is that, especially in engineering and especially in some of the areas where we have a lack of people today who are going into it, the lure of industry is very large. Computers are one particular example. Biotechnology, another example, where people who are coming out of universities with a BS degree, you know, can command very high salaries, and the cost of a Ph.D. is a very high opportunity cost that a lot of people just aren't willing to pay. So that's one reason.

The second reason, I think, has to do with what Miss Schneider focused on before, the environment in the universities. The best research you can only do if you have the best instrumentation, and if the best instrumentation is available in industry but not in a university, you have another negative factor that you have to consider.

So those are reasons. And third, the support of graduate students, you know, the continuing support of graduate students. For all of those reasons, we have focused on instrumentation; we have focused on graduate fellowships. We increased over the last few years the graduate fellowship stipend, even in light of the fact that the new tax law takes some money away from that. We are going to restore that to those people who are affected. We are increasing in the '88 budget by 200 positions the graduate fellowship program. That's a significant kind of an increase, so that we have more people that we can support.

The Presidential Young Investigator Program, while not attacking exactly this area, addresses a very related area, namely filling the faculty positions that are open.

Mr. **Ritter**. Mr. Bloch, if I could just interrupt because I don't want to take that much time, the 55 percent figure, how has that varied? You said that 55 percent of the graduate students are actually remaining in the United States. That's high.

I'm curious as to how that has varied over the years. Is that rising or declining or is it staying constant?

Mr. **Bloch**. It's my understanding that it has been increasing over the years, but I wouldn't—you know, I would not——

Mr. **Ritter**. I think we should—I would like if we could get some definitive information.

Mr. **Bloch**. Sure. We'll give you the data.

[Information to be furnished follows:]

NON-U.S. CITIZENS COMPLETING DOCTORATES IN U.S. UNIVERSITIES WITH FIRM POSTGRADUATION PLANS IN THE UNITED STATES

Doctorate recipients, by visa status	Percent		
	1970	1980	1986
Non-U.S. citizens, Total:			
Total Science/engineering	57	56	57
Science	55	51	53
Engineering	66	68	64
Non-U.S. citizens on permanent visas:			
Total Science/engineering	86	89	78
Science	86	89	76
Engineering	87	89	83
Non-U.S. citizens on temporary visas:			
Total Science/engineering	42	45	52
Science	41	38	49
Engineering	48	60	61

Note: Percents based on total reporting firm plans.
Source: National Science Foundation, SRS.

Mr. **Bloch**. But the point I want to make is the following; that that can change tomorrow morning. If the opportunities in the home countries are very large, people will go back.

Mr. **Ritter**. It would be my intuitive feeling that the opportunities in Japan, for example, in the Asian Rim nations, are increasing, and that this figure could be a declining figure, but that's an off-the-cuff intuitive statement.

Mr. **Bloch**. Well, that's my concern.

Mr. **Ritter**. I think it would be appropriate to better understand that with hard data.

What about the industry, in terms of graduate students spending the time incurring the opportunity cost as well as the direct cost—what does that say about industry demand for our doctoral level educated people?

Mr. **Bloch**. The industry demand has gone up. The biggest increase of Ph.D. employment is in industry and has been over the last four to five years. The increase has been greater than the increase in either the government sector or in the university sector. So that's something that industry needs—these people.

Mr. RITTER. Given that there is such an enormous percentage and that such a large percentage stay here, are our immigration laws sufficient to accommodate——

Mr. BLOCH. Well, Mr. Ritter, you're asking a question that has come to the surface over the last——

Mr. RITTER. I know Dr. Schmidt several years ago had made some pretty strong comments on this issue.

Mr. BLOCH. Well, let me tell you, I can't tell you the answer, but we'd be glad to supply that answer.

[Information to be furnished follows:]

REPLY TO CONGRESSMAN'S RITTER'S QUESTION ON THE IMPACT OF THE IMMIGRATION LAWS AND INDUSTRY'S ABILITY TO GET PHD-LEVEL FOREIGN SCIENTISTS AND ENGINEERS

As you know, the immigration laws (specifically, Title 8, U.S.C., section 1182) require many foreign students to return for two years to their native countries before being eligible to apply for an immigration visa, for permanent residence, or an nonimmigrant visa under 8 USC 1101(a)(15)(L). The last listed status is the one normally used for corporate or industrial employment of aliens who have special knowledge or skills, such as scientific or engineering expertise in a particular field.

The requirement may be waived by the Attorney General upon the recommendation of the USIA or the INS. Unfortunately, the grounds for granting such waivers under the existing laws do not appear broad enough so that the United States Government can easily make exceptions as our needs for more foreign PhDs increase. The USIA and INS do the best they can, we believe, but they can only go as far as the law permits.

We have supported legislation which would liberalize the waiver grounds to permit foreign graduate students in the natural sciences, mathematics, computer sciences, and engineering to stay in the United States. This legislation was section 312 of H.R. 3810, passed by the House on October 9, 1986. Unfortunately, the section did not survive the conference committee and did not become part of P.L. 99-603, the Immigration Reform and Control Act of 1986. We think this is an issue that needs further scrutiny and a possible change in the immigration law.

Mr. BLOCH. In fact, I just asked the Council to take a look at that, because I have heard in the last few weeks three or four times now, that it's more difficult to convert an individual who has a temporary visa to one that has a—convert that temporary visa to a permanent visa. I've heard that.

I don't know if that is true, and I don't know if it has its basis in law, or if it's just—it's just what each of the people have to go through, but we are looking into that question.

Mr. RITTER. Should we be concerned about the technology transfer as we develop these more focused Engineering and Science and Technology Centers? Should we be concerned about the technology transfer?

We hear that the Japanese universities are not equivalent to ours in terms of quality, and that they're perfectly willing to support, endow, and to send graduate students to the United States.

Mr. BLOCH. Yes and no. And let me explain why I'm saying yes and no. We should be concerned.

Mr. RITTER. That sounds like a political answer. [Laughter.]

That's the kind of answer Congressmen give.

Mr. BLOCH. Well, sometimes I use it myself. But let me tell you what I mean by that.

Yes, we should be concerned, but not to the point where we are going to close our universities. What we should do instead is make sure that we have equal access to the other countries.

Mr. RITTER. That's a really interesting point. The Florio Subcommittee on Consumer Protection and Competitiveness had people testifying yesterday—I guess it was Dr. Frank Press—testifying that the idea of, if not equal access, the idea of symmetrical access—and I mentioned this a little earlier—that this symmetrical access is awfully important.

Does the National Science Foundation have a role to play in stimulating the symmetrical access? We have had such problems in the trade arenas. The only times we've gotten a reasonable response from the Japanese, for example, is in the telecommunications MOS talks—right now we're engaged in, you know, semi-fisticuffs over the semiconductor access problem—the only time we've ever made any progress is when we have used a kind of stick-and-carrot approach where the stick is denial of access to the U.S. market.

What are your feelings on that? Where does NSF come in here?

Mr. BLOCH. Well, NSF is coming in, and I will give you an example. We did it in one particular case. We went to Japan, and we said we wanted to have access to the ICOT (Institute for new Generation Computer Technology) program. The ICOT program, as you know, is a fifth generation computer program, which is a standalone institute in the middle of downtown Tokyo, which is populated by people from industry, by people from government laboratories, and by people from the universities. And we said, "Look, you have access to our computer research in universities. We want access to ICOT. We want to be able to send two people at any point in time over there for an extended period of time, not for five hours, but for six months or twelve months, who can work with you, from a university, and then come back."

Mr. RITTER. What was the result?

Mr. BLOCH. They agreed. You have to push them. But we can do more than that.

Mr. RITTER. Dr. Press was talking about—this is the Harold Brown, the Dr. Harold Brown initiative with the Japanese, and to talk about symmetrical access, and I think this Subcommittee has to have a concern about that. Dr. Press' testimony essentially stated that access, that symmetrical access just does not exist at the present time, and that so much of the really interesting research is conducted in the industrial mini-laboratories, and there the access has been very, very hard to come by.

Mr. BLOCH. I know. It took me a long time to be able to walk through the ETL (Electrotechnical Lab), but finally——

Mr. RITTER. Well, yes. I had the pleasure of doing that a few years ago. But I must say that we may need to think in terms of not just jawboning on this issue, but to indeed consider an approach which has our own access as part of the bargain.

Mr. BLOCH. As we do that, I only hope that we are doing it in such a way that we are not hurting ourselves more.

Mr. RITTER. I understand. But if we keep saying to ourselves that we have to—you know, in doing something like this, we have to be concerned that we don't hurt ourselves more, that is a signal to the other side to say, "Aha, they're not really serious. We can negotiate. We can mediate. We can essentially drag feet."

And this has been the case to date.

Mr. BLOCH. Well, again, I'll say on the fifth generation computer project, when we became serious, it took three months to come up with that deal.

And, by the way, in the meantime, the French did the same, interestingly enough.

Mr. WALGREN. I thank the chairman for his indulgence.

Thank you, Mr. Bloch.

Mr. PRICE [presiding]. Mr. Boehlert?

Mr. BOEHLERT. Thank you, Mr. Chairman.

Mr. Bloch, I am vitally interested in what you're saying. I'm just down here. This is a designated smoking area. [Laughter.]

Mr. RITTER. Would the gentleman yield?

Mr. BOEHLERT. I'd be glad to yield.

Mr. RITTER. I would really like to commend the ranking member of this Subcommittee, because he understands the environmental impact of passive smoking and secondhand smoke like no other member of the Congress does. As a matter of fact, I, as the chief proponent on the House side, of the bill to conduct smoking in designated areas, was pleased as punch to have the ranking member of this Subcommittee, although a chain smoker at times, be an original co-sponsor to that bill.

Mr. BOEHLERT. Well, thank you.

Mr. RITTER. And that's just an aside. I yield back to my friend.

Mr. BOEHLERT. Thank you. I'm afraid—I'm sorry that is going to appear in the official record, my weakness there.

Mr. Bloch, one of the problems facing managers like you of big Federal programs, particularly now under the current climate, is to be effective in the management under the conditions where budgets are being slashed, but it's equally challenging in terms of an assignment to manage growth, and you pride yourself on operating lean, and that's your word.

Are you going to be able to handle 100 percent growth in five years with your present lean configuration?

Mr. BLOCH. Well, I'll say yes, and let me explain what I mean by that. As you know, if you look at our budget in detail, our salary, overhead, everything else that goes with it, of running the NSF per se, is on the order of about 5 percent of the budget, and I hope that we can keep it at or below that particular number.

Will we need more people? Yes, we'll need more people but I don't think it's proportional to the number of dollar increases. We are very far from it. We have taken precautions to make sure that that does not happen by essentially installing a lot of automated equipment, work stations and so forth, and as that becomes more productive, as people learn how to use it, I think we can hold it to that 4 to 5 percent level, at least that's the goal.

Mr. BOEHLERT. I am not lobbying for more people for you, understand, but with this new found recognition of the importance of the National Science Foundation and what you are about, there are going to be increasing demands on people like you and your Assistant Directors (ADs) for example, to move around the country, as I would encourage you to do, to speak and that type of thing.

Who is going to be running the store back here?

Mr. Bloch. Well, yes, the answer is yes, there will be more demand on time and as you say, to go around the country and some of that is certainly necessary.

Mr. Boehlert. Extremely important.

Mr. Bloch. And very important. We have a very able staff. We have very able ADs and a number of the ADs have very able Division Directors.

Mr. Boehlert. I'm not challenging that, Mr. Bloch. What I am suggesting though is you have a big increase, a big growth, forecast over the next 5 years and I think it is unrealistic for any of us to assume that you can handle that growth with the present complement or even a slightly expanded complement. Do you see what I'm driving at?

Mr. Bloch. I know exactly what you are driving at and that's a concern and let me say one thing. It's the worst thing you can do, to essentially assume that you need such an expanded staff because these are becoming self-fulfilling prophesies after a while. They all start with a very lean kind of a target, now what it means is that we have to attract to the Foundation the right people, and that we have to attract to the Foundation people that are capable of running a bigger operation and that will mean some changes internally; no doubt about it.

With the structure as it exists today, the pay structure in the Federal Government and so forth, we have some opportunities outside of that pay structure, and that is becoming very important, where we are attracting people for shorter or longer periods of time from universities, where we can attract the higher level kind of people, and that is very important. If you didn't have that blow out patch, as I call it, if you had to live within the pay structure itself, I think I would look at it in a much more pessimistic way than I do, but we have been able to attract outstanding people to the Foundation through that particular means, and I think we have to resort to that more and more at the high level end, and that doesn't mean across the board; quite the contrary.

No doubt about it, we have to resort to that scheme.

Mr. Boehlert. One further question, if I may, Mr. Chairman, with your indulgence. Shifting gears a moment, on the instrumentation program, which I view as critically important, what are your plans for the two year colleges and pre-college in terms of resources? More and more, we are seeing demand being placed upon the public institutions because of the high costs of higher education. More and more, the bright young student is going to the two year community college because that is affordable and I'm wondering what your plans are to help those two year community colleges and I'm looking even below that in terms of your instrumentation program.

Mr. Bloch. The two year colleges are eligible in all of our undergraduate education programs, so they can apply just like everybody else.

Mr. Boehlert. Haven't been doing very well though, have they?

Mr. Bloch. Well, we haven't had an undergraduate education program in place, so it's hard to tell, but with one exception. That's what I wanted to address, so as not to mislead you.

The exception is the CSIP program, or College Science Instrumentation Program essentially. That is for four year colleges only. That was discussed in Congress, and the way you came down was essentially it was a four year kind of a college program. So we have not opened that to two year colleges.

Mr. **Boehlert**. But if I recall correctly, we suggested from this Committee, to open that up. Was it a matter of dollars and cents?

Mr. **Bloch**. It was a matter of dollars, and dollars didn't materialize. There was language in the Appropriations bill that specified four year colleges only.

Mr. **Boehlert**. Well, are you going to lobby on behalf of opening it up this year?

Mr. **Bloch**. Okay.

Mr. **Boehlert**. The answer to that question is yes?

Mr. **Bloch**. No. We have not made the change to it. I understood you to say you would lobby——

Mr. **Boehlert**. Well, I will, but will you help me?

Mr. **Bloch**. I need to look at the dollars. The problem that we have is very simple, okay. We added dollars to this particular program, as you know, into various research directorates, and in those dollars, the two year colleges are eligible to apply. In the $9 million concentrated program, which is in the SEE Directorate, that's where we have the four year rule, but in the rest of it, which is about another $9 million, the two year colleges can apply.

Mr. **Boehlert**. Maybe you should be asking for more money in the area of instrumentation so that we can open it up, because as a practical matter, I don't think the money is filtering down. I don't see any evidence of it.

Mr. **Bloch**. I told Mr. Walgren before when he said that we asked for more money all across the board, including that program.

Mr. **Boehlert**. Thank you.

Mr. **Price**. Thank you. Mr. Bloch, I'd like to return briefly to the Engineering Research Centers. I wonder if you could, as specifically as you can, line out your future plans for the Engineering Research Centers and indicate how they are related to the plans in the budget request for Science and Technology Centers?

Mr. **Bloch**. Specifically, let me give you the status. We have 11 centers established; 13 universities, 11 centers. We are right now finishing up the 1987 solicitation. We will be able, with the 1987 budget and the increases for the existing centers, we will be able to fund about 3 new centers, because we have a rule from the Appropriations Committee that we have to fund for a full year. As the fiscal year might only require 3 or 4 months of funding.

Mr. **Price**. Three Engineering and Research Centers.

Mr. **Bloch**. That brings us up to 14.

Mr. **Price**. And that's a subset of these Science and Technology Centers?

Mr. **Bloch**. Well, you can look at it that way. I don't. I really look at the Engineering Research Centers as stand alone—as a stand alone program, because it started 2 or 3 years ago, and the Science Centers have not started yet.

In addition to that, we have a goal of 25 centers total, and that was the original number that was recommended at that time, 3 years ago, by the National Academy of Engineering, which helped us formulate that particular program.

With the 1988 funds that we have been asking for, we can probably fund in 1988—these things are not certain because you don't know what kind of proposals are coming in and how much money is required per center—we probably can fund another 5, and that would bring us to something like 19, and then we would have 6 more to go in 1989 and 1990. That's about where we are.

We have planned an increasing budget for existing centers in 1987 of roughly on the average, and again it varies from center to center, of about 9 or 9.5 percent, which is needed to bring these centers up to where they should be in terms of their capabilities.

In addition to that, as I mentioned before, we are going through an evaluation of the first 6 centers, that have been in existence now for 3 years, as we said we would. We have in the 1987 budget, $30 million, in the 1988 budget, we are asking for $48 million for the centers. That includes the existing ones as well as the new ones that we are planning for 1988.

Mr. PRICE. So your eventual goal is to have 25 of these?

Mr. BLOCH. The eventual goal has always been 25 and I think that is still a good number.

Mr. PRICE. And 11 are now in operation?

Mr. BLOCH. 11 are now in existence.

Mr. PRICE. And are selection procedures underway at the moment for 3 additional, you say?

Mr. BLOCH. Yes, the selection procedure—you know, we got 68 submissions. We visited 12 centers—site visited 12 centers. The proposal that we got was to fund 5 for sure and the other ones if we could. We can only fund 3 with the ruling that we got from the Appropriations Committee.

Mr. PRICE. Now, a primary criterion for ERC program selection is supposed to be relevance to the competitiveness of key U.S. industries.

Mr. BLOCH. Right.

Mr. PRICE. Do you have a list you could give us now or could furnish us later of which key U.S. industries have been related to the ERC's selected?

Mr. BLOCH. Well, if you look at the list, I'll submit one for the record, certainly, let me just characterize it for a minute.

The 11 centers that we have range from such things as combustion technology, which relates obviously to the automobile industry but not only, robotics, and robotics in microelectronics and robotics in the more general way, which can relate to many different manufacturing areas. There is a center on telecommunications which relates obviously to the telecommunications and computer industry. There are centers on materials, one on composites, one on ceramics, which relates to again a large number of industries, the composites—one to the aircraft industry, obviously, today with the automobile industry, and probably in those industries tomorrow.

There is a center on compound semiconductor microelectronics in Illinois which relates to the semiconductor industry. There is one on large structural systems; how does one do research on large structural systems, which again relates to many industries? There is a center on systems research which relates to all of the engineering areas. How does one design complex large kind of systems? There is one on biotechnology process engineering, it is really manufacturing of biotechnology materials, which relates to the chemical industry and the biotechnology industry obviously.

There is one on net shape manufacturing, which relates to all manufacturing industry that has structural—that creates structural devices and structural components.

A lot of them are very general inasmuch as they relate to many industries. Some of them are more industry specific.

Mr. PRICE. Good. It would be helpful to the Subcommittee if you would furnish a complete list for the record of the industries that are covered. I wonder when you do that, if you could also include information on the institutions selected.

Mr. BLOCH. Sure.

Mr. PRICE. And a breakdown on the regional distribution of the ERC's.

Mr. BLOCH. All right.

[Information to be furnished follows:]

ENGINEERING RESEARCH CENTERS—INDUSTRIES, INSTITUTIONS, AND REGIONAL DISTRIBUTION

The 11 centers established during FY 1985 and FY 1986 are listed below, along with the major technological areas upon which they focus, and the industries which they can be expected to significantly impact:

East

Carnegie-Mellon University—Engineering Design.

Industries: general manufacturing, computers, automotive, aircraft.

Columbia University—Telecommunications Research.

Industries: electronics, computers, communications.

University of Delaware/Rutgers University—Composites Manufacturing.

Industries: automotive, aircraft, plastics and composites, construction, general manufacturing.

Lehigh University—Advanced Technology for Large Structural Systems.

Industries: construction, steel and concrete, transportation, composites.

University of Maryland/Harvard University—Systems Research.

Industries: electronics, computers, communications, transportation, general manufacturing.

Massachusetts Institute of Technology—Biotechnology Process Engineering.

Industries: pharmaceutical, food processing and agriculture, energy, waste removal, manufacturing.

Midwest

University of Illinois-Urbana—Compound Semiconductor Microelectronics.

Industries: electronics, computers, communications.

Ohio State University—Net Shape Manufacturing.

Industries: general manufacturing, steel, plastics and composites.

Purdue University—Intelligent Manufacturing Systems.

Industries: general manufacturing, automotive, materials processing.

West

Brigham Young University/University of Utah—Advanced Combustion Technology.

Industries: petrochemicals, energy, automotive, aircraft, materials processing, general manufacturing.

University of California-Santa Barbara—Robotic Systems in Microelectronics.

Industries: electronics, computers, general manufacturing.

The National Science Board recently approved the establishment of two new centers in FY 1987. They are:

University of California at Los Angeles (West)—Hazardous Substance Control.

Industries: general manufacturing, petrochemicals, nuclear energy, microelectronics, sanitation and waste treatment.

University of Colorado at Boulder (Midwest)—Optoelectronic Computing Systems.
Industries: electronics, computers, communications, general manufacturing.

The NSB approved a third center in FY 1987, subject to co-funding by the National Institutes of Health. It is:

Duke University (Southeast)—Emerging Cardiovascular Technologies.
Industries—health care delivery, medical instrumentation.

Mr. **Bloch**. By the way, on that particular point, let me just make a point on that. I think—I mean 11 centers is not a large number of centers but these 11 centers are very well distributed both geographically as well as from an institution's viewpoint. What do I mean by that? By that I mean they are not all concentrated into upper tiers of the universities but really go across the spectrum of universities as much as 11 centers can go across the spectrum.

Mr. **Price**. What are the criteria; we are dealing with this general relevance to competitiveness as a criteria, but are there other criteria you might specify that go into these selections?

Mr. **Bloch**. Sure. What goes into the selection is first of all, obviously, the research itself, you know, the excellence of the research. Is it a worthwhile thing to do, number one?; does this particular center or particular university have the wherewithal to bring it off, that's a very important thing?

The relevance that you mentioned to industry, which we are primarily getting by asking how industry participates. If industry participates on a grand scale, they have an interest in it. If they put money in it, they have an interest in it.

We are also asking about the state participation. By the way, that doesn't apply only to state universities. That applies also to private universities, because we have cases like the telecommunications one which is in a private university, Columbia, where the state put a building up for that particular center. So we are asking for that.

Mr. **Price**. Excuse me. Is that uniformly a feature of these projects or is that unusual?

Mr. **Bloch**. No. I don't know if it is unusual, but it's not uniform, and it's not a requirement either. We left it pretty loose as to what is a requirement.

Mr. **Price**. But state involvement, state governments——

Mr. **Bloch**. State involvement is very important.

Mr. **Price**. Demonstration of interest and willingness to invest in this would be a positive factor?

Mr. **Bloch**. Absolutely. We have one, the University of Delaware, together with Rutgers University, where the state, both states, have contributed very heavily, again in terms of facilities.

Mr. **Ritter**. If the gentleman would yield, the Large Scale Structures Engineering Research Center has received a very significant amount of support from the State of Pennsylvania.

Mr. **Bloch**. Right.

Mr. **Ritter**. Their so-called Ben Franklin partnership to stimulate the development of the advanced technology industries in the state. That's an excellent partnership, as a matter of fact.

Mr. **Bloch**. That center is at Lehigh University.

Dr. **Moore**. Mr. Price, let me just add a couple more. Mr. Bloch has already referred to one, the educational component of these centers, which is a very important part of our evaluation criteria. I would add in connection with the capability of the university, the university commitment itself to the center, which may involve things such as the provision of faculty positions for the center and for the release time of faculty members to participate in these centers. But I think the university's commitment and the design for education of both undergraduates and graduate students are also two important criteria.

Mr. PRICE. In your view, are there any major omissions at this point in terms of industries that have not been involved, have not been covered?

Mr. BLOCH. Absolutely.

Mr. PRICE. Could you specify a little bit on that?

Mr. BLOCH. You know, from the list that I gave you, you see very little in here on, for instance, steel making as one particular example. You see some of the other industries not represented, textiles, for instance, and so forth. There are some areas in here that, again, you know, one should be very careful. You can't cover every industry, but you can cover subject areas, research subject areas that deal with the whole range of industries, and I gave you some examples.

One of the ones that has been submitted from time to time is being submitted this year and has to do with research on waste disposal and recovery, which applies to everything. So one wants to really watch out that we don't focus just on industry but focus on areas of research that are important to a large number of industries, not all industries.

Mr. PRICE. Has the semiconductor industry been involved to any great extent?

Mr. BLOCH. Yes. The semiconductor industry has Compound Semiconductor Microelectronics, a center that was established last year. It has to do with gallium arsenide, in particular, a very important kind of a new area, a relatively new industrial area for semiconductors. So they have been involved.

In addition to that, by the way, let me point out we have other activities going on in the Foundation that have to do with other types of centers which have been in existence for some time. We have Materials Science Centers in existence in a number of areas that deal with many materials that are very important to industry, and so forth, so you shouldn't just look to these particular Engineering Research Centers if you want to see the totality of our involvement with various industries or research areas that are important to various industries.

Mr. PRICE. I understand. Thank you.

Mr. Boehlert has another question.

Mr. BOEHLERT. Yes, Mr. Bloch. You probably are aware of the fact that one of our colleagues from Minnesota appeared before the Committee just recently and had some reservations about the supercomputer initiative and some questions about the future. His basic premise was that you should not proceed with your plan, as he understands it and as I understand it: that is, to have NSF-supported researchers use NSF-supported supercomputer centers. He was saying let them go wherever they want.

Would you address that specifically and in general comment on his questions about the supercomputer initiative?

Mr. **Bloch**. Yes. Let me address this. I am aware of that particular testimony, and let me make a number of comments. The Phase II centers were established with exactly that idea, that they are available to everybody, and are not the exclusive use of the local researcher or of a local university, and we have taken great pains in making sure that happens.

Before we could establish the Phase II centers, there were some Phase I centers that we took advantage of, and one of them is the Colorado State University Center and the other one is the Minnesota Phase I Center. Those people were put on notice right from the beginning that this was a temporary arrangement while we were establishing the five—at that time it was more than five—Phase II centers. We would take advantage of their capabilities and buy time from them. We have done that.

We have also phased them out, with the exception of the Minnesota Center, which has this year about $1.5 million—and most of it has been used up by the way—available. All the other centers have been phased out. So that has been our plan right from the beginning. I think it is right that we are putting our researchers onto the Phase II centers. We established them for that reason, number one. We took great care to make sure that it was the best bargain in town by making sure that manufacturers contributed to it and states contributed to it. The cost per cycle time is much lower than in the other centers, so it is a bargain for the Federal Government.

So it is no surprise that we phased out the Phase I centers, and I don't think we have any further obligations except where we could use their services, and we are always going to look for that. So I would say that what we did with the Phase I centers is not a surprise at all. It was in the plan, and what we are doing with the Phase II centers is an efficient way of operating.

Mr. **Boehlert**. So what you are saying, essentially, is that you had a plan and everyone knew the plan and you are sticking with the plan.

Mr. **Bloch**. That's right.

Mr. **Boehlert**. I have no quarrel with that.

Mr. **Walgren** [presiding]. The Chair recognizes the gentleman from Pennsylvania, Mr. Ritter.

Mr. **Ritter**. Thank you, Mr. Chairman.

Mr. Bloch, in my opening comment I mentioned that research priorities were not set in a vacuum, and obviously it is always a tough process to understand which are the most important areas and then to perhaps do something about it given the fact that you are also driven by what has happened in the past.

What is the status of manufacturing sciences and also the underpinning of manufacturing in many ways, engineering, in the Foundation these days? Where have we been and where have we come?

Mr. **Bloch**. Let me try to characterize it, and then maybe Nam Suh [2] wants to add to it. Let me start with the engineering, the totality of the engineering effort in the Foundation. It has been on the increase over the last few years. In fact, over the last three years, including 1988, the biggest percentage increases are going to engineering. Engineering is getting, in 1988, if we get this budget through, something like a 26 percent increase, which is much larger than anything else.

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[2] Dr. Nam Suh, Assistant Director for Engineering, National Science Foundation.

Related to engineering you have to look at another directorate, namely, the Computer and Information Science and Engineering Directorate, because some of that is science and some of it is engineering, and you shouldn't draw the line between the two, because I don't, and that is getting a 23 percent kind of an increase.

So those two directorates together are getting the biggest percentage increases in the Foundation.

Secondly, in many of our activities, especially in the Center activities, we are paying specific attention to manufacturing. I mentioned before the Biotechnology Center, which is really not a Biotechnology Center in terms of development or basic research; it is really a Biotechnology Center in terms of manufacturing: what are the manufacturing issues and questions that have to be dealt with as one scales up production and puts things into production in the biotechnology area?

The whole area of materials, ceramics and composites, that I mentioned before. A lot of that work is aimed at manufacturing research rather than at basic materials kind of questions.

There is a fine line between manufacturing and development kind of activities, obviously, and many times you can't or you don't want to draw the line. Many of the areas where we have research going on, in CAD/CAM areas, for instance, computer-aided manufacturing, computer-aided design, they all relate to manufacturing in one form or another.

So I wouldn't want to characterize, I wouldn't know how to characterize, what percent of our engineering budget goes to manufacturing and what does not, but we are aware of the problem, of the fact that universities have not really done much work in manufacturing research, and that has to change.

Mr. Ritter. That is an interesting point and I know it is the past, but the past is prologue and it does serve as an example.

Why did we essentially miss the boat on manufacturing sciences and engineering and the linkage to the——

Mr. Bloch. I will let Nam Suh talk from an academic viewpoint, but let me talk from an industrial viewpoint because I think I understand industry very well. It was a neglected area. What was important? What was important was development, essentially, and then manufacturing was an afterthought, and it has been treated as an afterthought. It was a mindset and a cultural thing.

As a consequence of that, you were not able to attract the best people into manufacturing. The people that went into manufacturing were people that didn't hack it in research or didn't hack it in development, very clearly.

Mr. Ritter. Why was it a mindset?

Mr. Bloch. Why was it like that?

Mr. Ritter. Yes.

Mr. Bloch. Because the interesting work was going on in development, and we didn't have much competition. There was a lack of competition. See, the Japanese have taught us something, and what they have taught us, and we should be eternally grateful to them even if it hurts, is essentially that problems in manufacturing are as important as in development. They are as scientific as in development.

Mr. **Ritter**. You say that the problems in manufacturing are as important or are at least as important—we heard this from the semiconductor people the other day—as product development? Is that what you are saying? When you are saying development, you are saying product development?

Mr. **Bloch**. That is right.

Mr. **Ritter**. Dr. Suh.

Mr. **Bloch**. Now Dr. Suh can talk about the academic non-interest in manufacturing.

Dr. **Suh**. I think you are raising a number of issues which are complex and difficult to explain in a few words. I think we have to look at this in the historical context. First of all, let me start out by saying that three problems are being dealt with here when we talk about manufacturing. One is a people problem, the second is an infrastructure problem, and the third is a knowledge problem. I think all three of these are equally important, so let me address each one of these and maybe it will bring out the historical reasons for it.

When we talk of the people problem, we are really talking about people problems both in universities as well as in industry. Over the years, university research emphasized more product-oriented kind of research because much of the so-called research philosophies of our universities came about because of the Second World War, and afterwards they were continued. A great deal of funding came from defense-related areas and other areas where they are always interested in better gadgets and better things rather than the process by which we make these things.

As a consequence, the ones which got the greater support for research were the ones who were interested in those kinds of things rather than the people who were interested in process-related things. So products obviously got the greater attention. With Sputnik and so forth, a great deal more emphasis was given to engineering science, as you know, and because of that, people who were working in the area of what I call technology-driven areas were driven out of the university system.

In fact, a large number of universities eliminated even tenured people in areas like design and manufacturing, all of which are technology-driven areas, because they thought engineering schools ought to simply emphasize science-driven areas.

Mr. **Ritter**. Excuse me for an interjection. Is that also because the pot of gold at the end of the rainbow was in the engineering science area? The funding for research support was there, and it wasn't there in the other area.

Dr. **Suh**. Sure.

Mr. **Ritter**. So the Federal Government has some role to play in that past?

Dr. **Suh**. The university, the culture has been built up around publication of papers, scientific papers or papers that can be published in journals, the ability to get funding for that kind of research. When you do not have funding for manufacturing-related research or design-related research, people cannot do research and they cannot hire graduate students to work on research projects, and then they find it seems there are not too many people engaged in research in these areas. There were no journals in which they could publish their results. Therefore, they could not get papers in refereed journals, and therefore universities did not give them due credit.

Mr. RITTER. Is this changing?

Dr. SUH. It is changing very slowly, but the problem is that since we did not create the infrastructure, since we sort of eliminated, if anything, this infrastructure needed for manufacturing and design education, what happened was as we tried to build up these areas, we found that we do not have the basis on which to build.

So there are a large number of universities now engaged in manufacturing education, but I really doubt the quality of the programs because we do not have a sufficient number of well-educated people in these areas and therefore it is going to be a long——

Mr. WALGREN. Will the gentleman yield?

Mr. RITTER. Yes, I sure would.

Mr. WALGREN. How can we track the emphasis on manufacturing research in your budget?

Dr. SUH. That is very simple. We have given a great deal of emphasis to manufacturing and manufacturing-related areas like design, computer-integrated engineering and so forth. The way we have done this is first of all by creating a separate division to deal with design manufacturing and computer-integrated engineering. So we have now a separate division that has been getting one of the highest budget increases next to the ERC program, and another thing we have done is we have brought a large number of good people in to deal with this issue.

In addition to this, I have been an advocate within the National Science Foundation that we have to pay much greater attention to undergraduate education in engineering because in engineering, a BS degree is the terminal degree, and a large number of these BS level engineers are the ones who eventually will go into the manufacturing area. So unless we deal with undergraduate education, we will not be able to adjust this manpower problem in industry because, as you know, 78 percent of our engineers in industry hold only BS level degrees.

The worst part of this personnel problem, that I was talking about earlier, in industry is that a large number of our engineers in manufacturing and in industry do not have formal educations. Even industry believed that they really did not have to have the best brain or brains in the manufacturing area because they thought it was not going to affect their competitiveness.

Mr. RITTER. If the gentleman would yield back, I think we have hit on a very serious topic here, a very serious problem. You can get to a point where, because percentage increases look substantial on paper, you think that you are moving very fast, but if it is a large percentage increase of an essentially small process, you still have a major problem. I think Dr. Suh has pointed out something that this Subcommittee, I believe, must pursue if we are going to play the appropriate role in the competitiveness issue.

I would just like to add that at the University of Santa Barbara, the Engineering Research Center there is managed by an ex-AT&T scientist, and it is my understanding, and correct me if I am wrong, that they are criticized somewhat within the University of California system as being a little bit too much out of the mainstream of the existing academic order.

I don't know if I am saying that correctly, but that is what it seems to be.

Dr. SUH. Let me comment on that. First of all, at the University of California Santa Barbara, the professors who are leading the ERC at that campus were trained as physicists, all three of them, and they are now in the Department of Electrical Engineering and they are trying to do engineering research work based on the experience they have gotten at AT&T, and overall I think they are doing a good job.

In areas where they are deficient, they have brought in a number of people from outside, including researchers from Japan who can teach them something about mechatronics, or the mechanical electronic device area.

Mr. RITTER. They have had to go to Japan to get some of those skills?

Dr. SUH. That is one of those areas where we are very weak.

If I might just continue the issue that you raised in the response to that. I said there were three issues and one is personnel, and that exists both in universities and industry. The second one was infrastructure, the fact that we haven't had infrastructure for educating manufacturing engineers, and that is still the case. The third one that I talked about is knowledge.

The reason people go to the university is because this is the place where they can get a great deal of accumulated knowledge in a systematic and coherent manner. They get the knowledge directly from professors who package this knowledge in such a manner that younger people can understand it because the knowledge has been generalized, and codified. They use the paradigms and whatnot so that young people can easily absorb the knowledge that has been accumulated over the centuries.

But in the case of manufacturing, that kind of knowledge does not exist today, and therefore university professors tend to teach experience, which is difficult to teach; and the reason they teach experience, their own experience and the experience of other professionals, is because knowledge has not yet been codified, because there has not been enough research done so they don't really know how to codify nor generalize. Therefore, they can only teach students some experience-based knowledge. We have to overcome this problem.

Because of this reason, at the National Science Foundation we have given emphasis to creating infrastructure by creating a separate division. We have been trying to create a knowledge base by supporting a great deal of research in this area, by increasing the budget for these areas at the expense of, because of a limited budget, at the expense of other fields, and then we have been trying to see how we can encourage undergraduate institutions as well as graduate institutions to create infrastructure by coming out with some special programs.

I think the problem is rather extensive. It is going to take many years to overcome this problem. This cannot be done overnight, and I have a feeling that——

Mr. Ritter. I think I speak for the Chairman and the rest of this Subcommittee when I say that we are here to do what we can in terms of what our role is to help you achieve that goal because I think it is an extraordinarily significant goal.

Mr. Walgren. If the gentleman would yield back.

Mr. Ritter. Yes.

Mr. Bloch. Mr. Chairman, could I comment? First of all, let me make one point with regard to manufacturing. I think we have gotten into the habit over the last 50 years, and it has been over that period of time, of dissecting our manufacturing operations into minute parts, a tool over here and a tool over there and a tool a couple of rooms away. The Japanese have done something entirely different. They have looked at their operation as a total, as a system, and they have done a top-down analysis.

That is the right way of doing it, especially in this day and age where we have intelligent terminals, where we have computers, where we have intelligent machine tools that are all interacting. And I think we have to learn that approach. And many of the programs that Dr. Suh has in his area are really trying to build a research foundation for that.

The second point I want to make with regard to the National Science Foundation; don't just look for labels which say manufacturing on it. We have many programs that pertain to manufacturing, and they are spread throughout Dr. Suh's operation. We gave you the example of four or five Engineering Research Centers and so forth, but we'll be glad to supply you with a cross-cut that lists for you and accumulates for you the areas that have manufacturing involvement and manufacturing importance.

Mr. Walgren. I would appreciate that very much because I think there are two areas that we as a Committee are particularly focused on. One is education and the other is manufacturing. And the emphasis that Mr. Ritter puts on it is certainly one that we want to develop.

Let me ask in that cross-cut, if it makes sense, at some point in there is a subset of automated manufacturing I gather, as opposed to perhaps other elements of manufacturing?

Mr. Bloch. Correct.

Mr. Walgren. And it's my understanding that some views of that in the recent past have been shown very limited support. That if you focused on automated manufacturing you wouldn't find an awful lot in the National Science Foundation budgets in 1984 or thereabouts. In that cross-cut would you direct gur attention towards those programs that you feel are really coftributing towards the development gf that, because that is part and parcel of substantial gains in productivity?

Mr. Bloch. Sure. (See insert p. 326 on ERC's.) Let me make another point. There are other parts of the federal government's R&D budget in other Departments and Agencies that have a direct involvement with manufacturing.

Mr. Walgren. Can you cite them in this kind of a display as well? Not right now, but I mean in laying out a cross-cut of your own Agency, apparently you're relying on the presence of some other Agency efforts from other Departments.

Mr. BLOCH. I think we can try to indicate the obvious ones. I'm sure we can't be exhaustive on it.

Mr. WALGREN. We would appreciate whatever perspectives you can give us on manufacturing as a discipline and as a focus.

Let me ask—time is going to run out on us and we've gone on for some time—but going back to community colleges and two-year colleges. The role of the National Science Foundation has been little if non-existent in relationship to them. And I would really want to direct your attention towards their role in this total pipeline of capability, human resource capability. And particularly, in the area of some kinds of technician training in view of the access that many, many people have to these institutions in their communities. It seems to me to be a real opportunity to have a broad-based programmatic effect without being involved in its school's programs, per se.

My question is, in the range of education development, can the National Science Foundation play a role in technician training programs or the development of them for the two-year colleges?

Mr. BLOCH. I would say the following. That as we develop the undergraduate education program we don't differentiate between two or four-year colleges, in particular, as we develop the curriculum part of that particular program. I have no doubt about it that some of that one will find its way, not just into the four-year colleges, but into two-year colleges, because it has been the history always that two-year and four-year colleges really use similar, if not the same, kind of course material and curriculum material and so forth.

So by improving, essentially by focusing on undergraduate education, not differentiating between two and four year colleges, I suspect that we are going to see, if we are successful, a fallout into the two-year colleges. It would surprise me if we wouldn't. Calculus, electrical engineering and so forth.

Mr. WALGREN. Maybe I can ask for some kind of description of the curriculum development program for undergraduate educational levels that would indicate that we are making some contribution towards curriculum in areas that are applicable to the two-year colleges, because so many of our people and their opportunity to participate in new technologies, that's their contact point. And I would think there is some curriculum development that would be very applicable there.

Mr. BLOCH. As we develop the undergraduate curriculum initiative number 1, and also as we go through with the evaluation, we'll pay attention to that.

Mr. WALGREN. And I'd like particularly to raise the subject of technician training because it's my understanding that there is demand in that area, and certainly we need the highest skills. And I would hope that in our role of educating for the broadest interpretation of delivering the potential of science that that would fit in there as well.

Mr. BLOCH. I need to say that much of the technician training curriculum has to do with hands-on kind of training and so forth, and vocational kind of training. You can't hold the National Science Foundation responsible for that.

Mr. Walgren. I understand.

Mr. Bloch. The part of it that is science and engineering essentially, and fundamentals in science and engineering, as I said before, I think that the four-year or that the undergraduate curriculum program can be used either directly or tailored after the fact to apply to that group equally.

Mr. Walgren. Let me then raise the question of the partipation of the social sciences in the growth that we anticipate in the Science Foundation. You indicated earlier that science education was going to have an increasing percentage, even given the growth.

It's my understanding that we still are not back to 1980 levels in the social and behavioral sciences, and that we're about 30 percent below in real dollars, constant effort measured from 1982. What can you tell us about the participation of the social and behavioral sciences in the growth that we are anticipating?

Mr. Bloch. In the growth area, social and economic science has a 13 percent increase, a 13.3 percent increase from roughly $32 million to $36 million between 1987 and 1988. I'm not sure about your statement that you made before that we are still not back to the peak.

Mr. Walgren. Let's look at it together sometime.

Mr. Bloch. I thought we were.

Mr. Walgren. We don't need the answer right now. My point is to raise it with you.

Mr. Bloch. We'll supply that.

[The material referred to follows:]

HISTORY OF SOCIAL AND BEHAVIORAL SCIENCE FUNDING AT THE NATIONAL SCIENCE FOUNDATION

[Dollars in millions]

	Fiscal year—								
	1980	1981	1982	1983	1984	1985	1986	[1] 1987	1988
Social and Economic Sciences:									
Current dollars	$31.4	$25.1	$17.6	$20.3	$24.6	$28.8	$27.8	$32.8	$36.0
Constant dollars	$37.1	$26.9	$17.6	$19.5	$22.7	$25.7	$24.1	$27.6	$29.2
Behavioral Sciences (BNS): [2]									
Current dollars	$21.1	$18.5	$15.0	$16.6	$18.6	$23.3	$21.7	$23.0	$25.8
Constant dollars	$24.9	$19.8	$15.0	$15.9	$17.2	$20.8	$18.8	$19.3	$21.0
Total Behavioral and Social Sciences:									
Current dollars	$52.5	$43.6	$32.6	$36.9	$43.2	$52.1	$49.5	$55.8	$61.8
Constant dollars	$62.0	$46.8	$32.6	$35.4	$39.9	$46.5	$42.9	$46.9	$50.2
GNP Deflators	0.8474	0.9321	1.0000	1.0423	1.0827	1.1200	1.1529	1.1887	1.2308

[1] Includes $1.05 million in funds carried over from FY86 in the Social and Economic Science Subactivity.

[2] Includes Psychobiology.

Source: NSF Budgets to Congress, FY 1976–1985.

Mr. Walgren. There's a fact there that will either support or shed light on that level of effort.

Mr. Bloch. But I want to say that in 1988 they certainly participate in the increase. And the increases that we have planned are in new areas as well as in the base itself. So I think we have done well by the social and economic sciences.

Mr. **Walgren**. Let me raise also under that the ethical values and the EVIST (Ethical Values in Science and Technology) program. That I understand you have met your commitment to spend $500,000 in that area. I hope it has a full representation in the new budget as well.

Mr. **Bloch**. Yes, but I thought it was $1 million that we spent in '86.

Mr. **Walgren**. Clearly, we all appreciate the——

Mr. **Bloch**. I'm corrected, $750 million. We split the difference.

Mr. **Walgren**. We certainly all appreciate the importance of stimulating attention in that area because certainly the direction of science from a value-based premise is critical. And the size of that program is small, to say the least. And we would hope that you would emphasize to the degree that it is at all possible.

Mr. **Bloch**. Yes, and I think we have done that. And as you know, we moved the program. We reorganized the program in terms of content and I think that's all for the better.

Mr. **Walgren**. The policy analysis effort would have the same arguments for it, I would gather.

Mr. **Bloch**. I don't know what you mean by that. If you mean by that that a couple of years ago we reduced that particular effort, that's absolutely right. But PRA, Policy Research and Analysis, is a very important function of the Foundation, and it's doing good work. And I would say that by reducing the budget, PRA was able to concentrate on things more in depth than being all over the place, and that was the object of the game.

Mr. **Walgren**. I see. I'd like to raise the Antarctic program if it was not raised when I was out of the room. And as I understand it, you're committing $13 million on a lease for an ice-resistant vessel of some kind that is—where we still would be dependent on the Coast Guard providing true ice-breaking capabilities. Are you satisfied that we're not going to be shut out because we can't break through the ice?

Mr. **Bloch**. We have an immediate problem. And the immediate problem essentially is that the ship that we have been counting on up to now, The Glacier, is out of commission. It can no longer be used, for safety reasons, for ice-breaking kind of purposes. So we've got to do something.

A new icebreaker that the Coast Guard has been talking about, and that has been under design, so to speak, is far in the future. It's five, six years in the future, if it happens at all. It has some other problems associated with it. We combined ice breaking and research capabilities in that ship, in the design of that particular ship. The cost of that ship is very high; it's over $300 million. And I don't know if the research end costs that or the ice-breaking end costs that. So it needs some re-evaluation.

In the meantime, we've got to live. So what you see in the budget is essentially capabilities and dollars that allow us to charter a boat that is available from the private sector. There are a number of them available, and we haven't decided, obviously, on one. We can make some modifications on a boat so that it can be used for research, and we can live in the meantime.

We've got to have that capability of doing research and moderate ice-breaking capabilities while we're waiting for a final solution, whatever that solution will be. This might be with us for a long time—I suspect it will be with us for a long time to come. So it's really an interim kind of a problem, and an immediate problem that we're trying to solve.

Mr. WALGREN. As I understand it, we're getting more and more interested in the Antarctic, particularly with respect to the ozone layer. And I hope, I guess, that some other Agency might come and help us with some of the funding that's necessary to get there. And that may or may not be possible. I know you certainly would want——

Mr. BLOCH. As you know the Foundation has the responsibility for the operation there, and the budgetary responsibilities. Obviously, we are supported by the Coast Guard and Navy, but we have the prime responsibility.

Mr. WALGREN. Given all the other responsibilities that you have, and the increasing interest of NOAA and EPA, I would think of what the implications are of that specific problem: perhaps they could join in.

Mr. BLOCH. In the research sense they are joining in. But I think we have to——

Mr. WALGREN. You still have to transport them?

Mr. BLOCH. We have to transport them, get them there and get them out of there, and supply them while they're there.

Mr. WALGREN. Maybe you could charge them a user fee for the transportation. That might defray the expense a little bit.

One other thought on teacher preparation and enhancement under science and engineering education. Apparently that's $36 million of, I gather, $115 million. Can you—what portion of that would be for the kind of summer institute type teacher enhancement program?

Mr. BLOCH. I'll ask Bassam to answer that question.

Mr. WALGREN. I'm getting to the point where I have to leave. Why don't we—I'm real sorry.

Mr. BLOCH. We can also submit the answer for the record.

Mr. WALGREN. Maybe we'll submit that for the record, if you would. I'm sorry, Dr. Shakhashiri, but I'm running out of time.

And I'd also be interested in the geographic distribution of the whole science education effort. There must be a way that you can display the reach of that geographically across the country because that would be a matter of critical concern.

Mr. BLOCH. I think what you'll find is that the distribution will be very impressive to you.

[The material referred to follows:]

REPLY TO CONGRESSMAN WALGREN'S QUESTION ON TEACHER INSTITUTES

Of the $36.0 million budgeted for the Division of Teacher Preparation and Enhancement in FY 1988, $22.3 million has been allocated for Teacher Enhancement projects. These funds support precollege teacher institutes and activities related to these institutes.

In addition, $3.0 million is budgeted for Undergraduate Faculty Development and $2.5 million for Career Access projects. Both of these programs will feature institutes for college teachers; the latter will focus largely on teachers from predominantly minority institutions.

Science and Engineering Education
Program Grants, Contracts
and Fellowships Awarded
FY 1986

SUMMARY (Amounts in Thousands of Dollars)	PROGRAM GRANTS AND CONTRACTS (Including Fellowships)		FELLOWSHIPS (Number of Fellows Supported)
	No.	Amount	
Alabama	6	139	3
Alaska	3	26	1
Arizona	8	501	12
Arkansas	6	116	
California	72	13,812	454
Colorado	20	1,791	14
Connecticut	8	957	41
Delaware	3	188	
District of Columbia	25	3,871	1
Florida	11	345	10
Georgia	14	1,784	11
Hawaii	4	107	1
Idaho	2	10	
Illinois	26	3,205	78
Indiana	16	1,193	21
Iowa	16	1,140	4
Kansas	6	380	6
Kentucky	8	152	1
Louisiana	7	81	2
Maine	6	74	1
Maryland	20	1,893	35
Massachusetts	48	11,426	326
Michigan	29	3,104	40

PAGE: 1

SUMMARY (Amounts in Thousands of Dollars)	PROGRAM GRANTS AND CONTRACTS (Including Fellowships)		FELLOWSHIPS (Number of Fellows Supported)
	No.	Amount	
Minnesota	22	1,209	18
Mississippi	8	576	
Missouri	13	983	10
Montana	4	652	
Nebraska	7	619	1
Nevada	3	23	
New Hampshire	6	164	1
New Jersey	12	2,440	79
New Mexico	9	571	6
New York	74	12,025	115
North Carolina	21	1,439	38
North Dakota	2	19	
Ohio	19	1,085	9
Oklahoma	7	439	3
Oregon	12	771	7
Pennsylvania	42	3,563	72
Rhode Island	4	81	4
South Carolina	10	618	2
South Dakota	2	10	
Tennessee	7	590	2
Texas	20	1,766	44
Utah	12	1,149	6
Vermont	7	63	1

SUMMARY (Amounts in Thousands of Dollars)	PROGRAM GRANTS AND CONTRACTS (Including Fellowships)		FELLOWSHIPS (Number of Fellow Supported)
	No	Amount	
Virginia	14	1,302	12
Washington	14	959	43
West Virginia	6	69	1
Wisconsin	18	3,173	37
Wyoming	3	59	3
UNITED STATES TOTAL:	732	82,310	1,576
FEDERAL GOVERNMENT TOTAL:	4	761	
U.S. POSSESSION TOTAL:	6	196	
FOREIGN COUNTRIES TOTAL:	20	286	16
GRAND TOTAL:	762	83,553	1,592

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Mr. **Walgren**. All right. I'm sorry we're sort of out of time, and obviously there's a vote over there on the floor that I have to respond to. We appreciate your coming and spending this time with us. We think you're doing a lot of good things and we want to push you in every way we can to do as much together as we possibly can. And so we'll look forward to talking to all of you in that context.

And I especially want to express appreciation for the various Division Directors accompanying you today. I think it's helpful from our standpoint to have you here even though we didn't have direct interaction in the witness sense of the word. But we look forward to talking to you about the things that you're doing in your own specific areas as well.

Thank you very much.

[Whereupon, at 12:15 p.m., the subcommittee meeting was concluded.]

1988 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

TUESDAY, MARCH 24, 1987

House of Representatives,
Committee on Science, Space, and Technology,
Washington, DC.

The committee met, pursuant to notice, at 9:39 a.m., Hon. Robert A. Roe (chairman) presiding.

Staff present: Dr. Grace Ostenso, staff director; Dr. James Wilson, science fellow; Bob O'Neill, professional staff member; and David Goldston, professional staff member.

Mr. Roe. I want to welcome particularly Mr. Bloch, Director of the National Science Foundation, and Dr. John Moore, his Deputy Director, to this hearing this morning, which is an overview hearing on the multi-functions of the National Science Foundation, per se.

The National Science Foundation, as we all know, plays a pivotal role both in the support of basic science and engineering research in the United States universities and also in the training of future generations of scientists and engineers. This role is critical to our nation's future since the ability to create and exploit new technologies is central to our ultimate security and economic well being. Basic scientific research and the education of scientists and engineers provides the base upon which future technological advances can be built. History has shown that a sustained investment in basic research contributes to economic growth, to an improved quality of life, and to enhanced national defense capabilities.

NSF is a relatively small Federal agency with a big impact. I want to reiterate that, it's a relatively small agency with an extremely important impact, in my judgment. Although NSF funding comprises only about 3 percent of the total federal R&D budget, it supports one quarter of the basic research carried out in universities where half of all basic research in the United States is conducted. Since World War II—speaking of science and research, we'd better do some science and research on that speaker system. Well, we'll try. Let's see how it works. The electrician is on his way.

Now, no matter how important we are with superconductors and colliders and everything else, we need the electrician to fix this, or we'll not know what we are saying.

Let's go on from there.

All right, let's start again.

NSF is a relatively small Federal agency with a big impact. Although NSF funding comprises only about 3 percent of the total federal R&D budget, it supports one quarter of the basic research carried out in the universities where half of all basic research in the U.S. is conducted. Since World War II, this partnership between the Federal Government and the United States research industry has—universities has produced superior scientists and engineers and has served as a nurturing ground for advances in science and innovation. This linkage between performance of research and training of new scientists and engineers strengthens both functions. NSF is a key player in sustaining this research and education enterprise.

The proposed NSF budget for fiscal year 1988 provides for an increase of almost 17 percent above the previous year. This is the first of five increases proposed by the Administration to produce a doubling of the budget by fiscal year 1992. This Committee approaches this proposal with a firm belief in the importance of NSF's contribution to the nation's well being and clearly the proposal is made at a time when there are concerns, and great concerns, about the health of the United States basic research enterprise, and there are also new research opportunities that are ripe for pursuit.

The Committee is most interested in the setting of priorities in light of the competing budget demands. For example, how will NSF balance the needs for restoring the university research infrastructure while expanding research support for new aras of high scientific opportunity, such as biotechnology and the computational and information sciences? Likewise, NSF has recently begun to stress multi-investigator science and technology centers to pursue new research areas at the interfaces of traditional scientific and engineering disciplines. This raises the question of how resources will be allocated so as to develop those centers while adequately sustaining individual investigator grants, with their proven flexibility and innovation.

Finally, NSF must confront the important questions of balance of resources between the two principal functions of the Foundation: support for basic scientific research and support for science and engineering education. We are all aware of the recent data which show a decreasing fraction of college students choosing science and engineering studies at a time when the total pool of college-aged students is declining significantly. Over the past 15 years, the proportion of our population engaged in science and engineering has declined appreciably, relative to other technologically advanced nations.

Meanwhile, the Federal investment in undergraduate and precollege science education dropped dramatically, and is now at a level well below that of the 1960s in constant dollars. At a time when the United States must compete against strong rivals in a global economy, these trends are most concerning, indeed. We must take strong action to ensure that the pipeline of scientists and engineers remains filled, and to maintain a large, technically literate, inventive and acceptable, adaptable workforce.

In the hearing this morning, we will review the policies, priorities, and plans of the National Science Foundation in light of the proposed budget growth in fiscal years 1988 and beyond. And we are pleased to have with us and want to welcome Mr. Erich Bloch, Director of the National Science Foundation, and Dr. John Moore, Deputy Director.

[The prepared opening statement of Mr. Roe follows:]

Opening Statement of Hon. Robert Roe

The National Science Foundation plays a pivotal role both in the support of basic science and engineering research in U.S. universities and also in the training of future generations of scientists and engineers. This role is crucial to our Nation's future since the ability to create and exploit new technologies is central to our ultimate security and economic well being. Basic scientific research and the education of scientists and engineers provides the base upon which future technological advances can be built. History has shown that a sustained investment in basic research contributes to economic growth, to an improved quality of life and to enhanced national defense capabilities.

NSF is a relatively small federal agency with a big impact. Although NSF funding comprises only about 3% of the total federal R&D budget, it supports one quarter of the basic research carried out in universities where half of all basic research in the U.S. is conducted. Since World War II, this partnership between the Federal Government and the U.S. research universities has produced superior scientists and engineers and has served as a nurturing ground for advances in science and innovation. This linkage between performance of research and training of new scientists and engineers strengthens both functions. NSF is a key player in sustaining this research and education enterprise.

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The Committee is most interested in the setting of priorities in light of the competing budget demands. For example, how will NSF balance the needs for restoring the university research infrastructure while expanding research support for new areas of high scientific opportunity, such as biotechnology and the computational and information sciences? Likewise, NSF has recently begun to stress multi-investigator science and technology centers to pursue new research areas at the interfaces of traditional scientific and engineering disciplines. This raises the question of how resources will be allocated so as to develop those centers while adequately sustaining individual investigator grants, with their proven flexibility and innovation.

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Meanwhile, the federal investment in undergraduate and precollege science education dropped dramatically and is now at a level well below that of the 1960's in constant dollars. At a time when the United States must compete against strong rivals in a global economy, these trends are disquieting. We must take strong action to ensure that the pipeline of scientists and engineers remains filled and to maintain a large, technically literate, inventive and adaptable workforce.

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[The prepared opening statement of Mr. Lujan follows:]

OPENING STATEMENT OF HON. MANUEL LUJAN, JR.

Mr. Chairman, and members of the Science, Space and Technology Committee, todays' hearing has the promise of being both an enlightened review of the federal government's support of basic research in the university and academic community, as well as challenging examination of current and future needs.

We have before us today an agency that has done extraordinarily well in promoting and revitalizing the U.S. in science, engineering and education. Unlike most agencies in the executive branch, NSF's track record in the last six years is quite exceptional. Under the current Administration, the National Science Foundation has successfully increased its resources to in excess of 66 percent. For FY'88, the Administration is requesting a further 17 percent increase. This brings the overall NSF budget up to approximately $1.9 Billion. That is roughly 83 percent since 1981. I might note that this increase would have been greater had the Congress been able to appropriate those levels requested by the Administration in the past six years.

Given NSF's and the Administration's commitment to fund the National Science Foundation at $3.2 Billion by 1992, the NSF budget will have already doubled by fiscal year 1989. It will again double by 1992. Clearly, it takes strong leadership to successfully compete within the long list of national priorities to attain the level of growth that NSF has received.

NSF has been distinguished by a comprehensive cross-section of American R&D with the 24 members of the National Science Board responsible for the policymaking of the Foundation. In addition, over the past six years, NSF has attracted two very able and prominent directors. Former director, Dr. Ed Knapp, and current director, Mr. Erich Bloch, have initiated several new efforts to revitalize the American educational and research enterprise. We have seen the initiation of the advanced scientific computing program, the engineering research centers, increased support for graduate students and undergraduate instrumentation, increased support for interdisciplinary research as well as the reestablishment of the Science and Engineering Education Directorate. This has all occurred under the leadership of these two gentlemen.

The fields of earth science, radio and optical astronomy, biotechnology, computer and mathematical sciences have all been areas of specific focus within the Foundation over the last six years.

Along with the success of NSF, comes the responsibility to see to it that the very nature and objectives of the National Science Foundation are upheld.

It is noteworthy that the Foundation has very successfully interacted with both state and local governments, and with American industries in leveraging its funds. While there are relevant and substantive relationships to be cultivated with these partners, it is also essential that the Congress, the National Science Board, and the scientific and engineering community see to it that the very purpose for which the Foundation was established in 1950, is not compromised.

It should be the goal of this committee to question and pursue the allocation of NSF resources, the partners that enter into agreements with the National Science Foundation, the role of the National Science Board in setting NSF policy, the responsibility of the Foundation to implement that policy, and the cultivation of basic research in light of the national focus on competitiveness and trade.

It is unfortunate that we were unable to hold this hearing at a time compatible with the schedule of the National Science Board. I would urge this committee to consider a future date when the National Science Board can come before the committee to discuss the many issues regarding the management of the Foundation, major initiatives being proposed for increases, and the future of U.S. science and engineering.

Mr. ROE. Before I make another comment or two, I will defer now to the distinguished gentleman, the Subcommittee Chairman, Mr. Walgren. Are there any comments you want to make?

Mr. WALGREN. Thank you, Mr. Chairman.

Only to welcome Mr. Bloch and Dr. Moore again. We had a rather detailed hearing two weeks ago or thereabouts, and for our part we really appreciate the forthcomingness that people at the National Science Foundation have extended to us, and we feel better able to discharge our responsibilities.

I think it goes without saying that there is no more important area for the future of our national standing than the long term development of science and technology, and we have seen a great turn-around in this Administration since the initial policy directions of 1980, and I think they deserve credit for that.

I think that we have to understand that these are very basic investments that we are making in the future, and should be considered so in the Congress as we try to allocate resources to put our country in the best position.

We have come a long way from the period when the—any spending on the National Science Foundation was considered to be too much spending and, in fact, there is a general consensus at this point that we are not doing enough in the basic investment in science and technology and science education. And so that is what has resulted in the Administration coming forward with a support for real increases in this area, and I think our Committee in particular as an authorizing Committee, I hope, would shift its mood as well, and take the responsibility to set out for the nation what we should be doing in this area.

I realize that there is a blend of rules in this budget process. There are other levels in the Congressional process that are more proper to address what we can do and what may be the absolute limit, but I would urge the members of this Committee to take the responsibility to set out what we should do, so that we can really look back 10 years from now and say that we led the nation in the right direction.

Thank you, Mr. Chairman.

Mr. ROE. I thank the gentleman from Pennsylvania.

The Chair recognizes the distinguished gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Thank you, Mr. Chairman.

We had the advantage of a rather detailed briefing from Director Bloch and Dr. Moore on NSF's proposed budget for FY '88 and looking ahead. It's an exciting story, you tell it very well.

I am convinced in a town where competitiveness is the buzz word, as we all know, you say it just like in the old Groucho Marx Show, the magic duck comes down and you win $25. When we are concentrating on competitiveness, there are two approaches to dealing with the problem of our monumental trade deficit. The one school of thought says we deal with something very temporary and artificial to address the trade deficit. You have tariffs and quotas.

On the other hand—and I subscribe to this school of thought—we are better off placing our resources on something that's permanent and very real which is the scientific and engineering genius of America. That's the way we are going to make the most headway towards solving the problem of our trade deficit crisis.

So I welcome Director Bloch and Dr. Moore here this morning. I look forward to your story.

Mr. ROE. I thank the gentleman from New York.

Now, Director Bloch, we are ready for you. We have your statement and, of course, it will be entered in full in the record without any objections, but I think the statement is excellent and very hard-hitting, and it might be well to reflect on the totality of that statement, because I think it says a lot. So if you want to respond to that and do your whole statement, the Chair would appreciate it. If you want to summarize, I leave that to you.

STATEMENT OF ERICH BLOCH, DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY DR. JOHN MOORE, DEPUTY DIRECTOR

Mr. BLOCH. Thank you, Mr. Chairman. I prefer to summarize it as much as I possibly can.

The statement has a lot of examples in there which I am refraining from citing here. That's really for night reading for members of the Committee.

First of all——

Mr. ROE. For me and the Budget Committee. [Laughter.]

Mr. BLOCH. All Committees. You are right.

Before I start, let me apologize for Dr. Roland Schmitt, the Chairman of the National Science Board, who cannot be here today. He has to be on business in Japan, and he sends his regards.

[The prepared statement of Dr. Schmitt follows:]

REMARKS OF DR. ROLAND W. SCHMITT, CHAIRMAN, NATIONAL SCIENCE BOARD

Thank you Mr. Chairman. I appreciate the opportunity to add my comments to those of Mr. Bloch. My views on the issues before us are shaped by the two roles I fill—one on the National Science Board, and the other in industry. From both perspectives, I see Federal support for research and education as essential—both for national excellence and for competitiveness in the world economy.

In making our nation more competitive, Federal support of science and engineering research is absolutely vital. It helps insure a steady supply of young people educated in all the fields needed by technology-based industries. It helps supply the basic knowledge that makes possible new products and processes. Industry can meet many parts of the competitiveness challenge by itself, but in these two areas—training and basic knowledge—it depends on the excellence of our universities, which in turn depends in large part on government funding.

You've shown you understand this by your past support, so I'll make just a few remarks about important new themes in this budget.

The first is people. The nation has failed in recent years to attract enough of our best young people to science and engineering. We see this in declining enrollments, and in the rising proportion of foreign nationals in some of our most important science and engineering programs.

The problem is not with these foreign nationals. The fact that we are attracting them in large numbers says something very positive about our system. Many of them stay here, and we need them.

The problem is with people born in the U.S. We need to make careers in science and engineering more attractive to them. We have to provide the kind of incentives that will lead a growing share of bright and capable students into careers in science and engineering. We have to continue our efforts to make sure that nobody in our society gets discouraged from entering a career in science and engineering for reasons of sex, or race, or anything else not related to the ability to contribute. All this cannot be a one-shot effort. It requires long term programs, spread throughout the nation, and acting all the way up the line from the elementary school through the graduate school. The NSF is putting in place the programs to meet this challenge.

Let me add here a comment about the way these programs are managed. The Foundation is unique among Federal agencies in having a board that is actively involved in setting policy and in oversight. When the Foundation undertakes a new initiative, the Board makes sure mechanisms are set up to keep track of its accomplishments. We've done this for the special efforts of the Research Directorates, and we are doing the same thing in education.

Another major theme in this budget is "Centers". It's a reflection of the ways that science and engineering research are changing. Many of the most exciting opportunities require interdisciplinary approaches, large scale instrumentation, and group efforts. Many of the most promising research fields grow out of industrial challenges. The NSF has responded by placing more emphasis on centers. This is a good example of the way it is taking a leadership role in stimulating the changes that the university community needs to make.

But one should be clear about the nature of this change. It is a change in emphasis in the organization of research. But it is not a change in the basic mission of the

NSF. It is not a shift from basic to applied research. For a long time, NSF has supported centers in such areas as astronomy and materials, and they have always been involved in basic research. The idea of industry-university linkage represented by the new centers is also not new. That linkage has traditionally been stronger in the U.S. than in other nations, and this has given us a competitive edge. The centers offer ways to make that linkage even stronger, and take even better advantage of it than we have in the past. But this does not change the basic mission of the NSF or the universities, or the basic principles of the national R&D partnership among industry, universities and the government.

Mr. Chairman, as the nation looks for ways to improve its economic competitiveness, it must recognize that education and research are the basis of competitiveness. In the short term, policy measures such as changes in the interest rates or exchange rates may have more immediate impact. But in the longer term, our living standard depends on our productivity. And our productivity depends overwhelmingly on having smart, well educated people who can create new ideas, and then turn them rapidly and efficiently into new products and new processes.

So the dollars supporting the Foundation's programs are investments in the nation's future as a winner in world economic competition. They deserve your full support.

Mr. Bloch. Also I would like to congratulate you, Mr. Chairman, as you take over this Committee. This Committee has established a long record of strong support for basic science and engineering and for science and engineering education. That support has been greatly appreciated, and under your Chairmanship I know that that support will continue.

We will look forward to working with you on some of the most important questions that the nation will deal with in the coming years, and that have already been hinted at by you and the other members of the Committee who spoke before.

I want to discuss and focus on four items: economic competitiveness, and I think that gets me $25, according to Mr. Boehlert; the Federal R&D budget in total; the NSF's role within that budget and the strategic emphasis that we are placing during this budget cycle and future years' budget cycle.

Let me talk about economic competitiveness. It has moved onto center stage. For too long we have seen the source of our economic problems as a result of unfair trade practices or lower wages in other countries, or unfavorable exchange rates. But recently I believe we have realized as a nation that if you want to compete successfully, it comes down to creating new and better products, manufacturing them efficiently, selling them at competitive prices, and being first in the marketplace.

We can succeed if we look to our own resources, of which the most important ones are knowledge and well-educated people. These are the key elements of a competitive economy. New knowledge, which we get through basic research, is important because it provides ideas for new products that we need to compete in high technology areas, as well as in low technology areas.

It also helps us improve new technology manufacturing and service industries in total.

Education is important because talented and well-trained people are the source of the ideas and the main resource needed to put them into practice. New knowledge and education are prerequisites to economic strengths. Other things have to fall in place, but I believe that without new knowledge and education and educated people, anything else we do is futile.

Both knowledge generation, and education of scientists and engineers are responsibilities of universities, and that is why it is so important to increase investment in our universities. That is the central mission of the National Science Foundation.

Another point needs to be made. Better coupling between the people in institutions that generate new knowledge and those that need that knowledge is very, very important, and NSF can play a major role in making that happen.

Let me focus on the R&D budget for one—on the Federal R&D budget for a second.

There are two sides to that story. On the positive side, it has doubled from 1980 to 1987, from $33 billion to $63 billion. Since 1980, civilian basic research has increased from 20 percent to 45 percent of the Federal civilian R&D budget. The NSF budget has increased by 65 percent in the same timeframe. But despite these increases, basic research as a percent of the total Federal R&D budget has been dropping; it has been dropping from 18 percent to 14 percent. Federal R&D to universities likewise has been dropping, from about 15 percent to 12 percent of the Federal R&D budget, and Federal civilian R&D is 30 percent of the total Federal R&D budget today, give or take a couple of percentage points. It was 50 percent for a long time. And as a consequence, we are spending less on civilian research and development, as a percentage of GNP, than Japan and some of the other European nations are spending.

We need to rebalance the R&D budget. The David Packard and Allan Bromley Chairmanship of the White House Science Council has advocated doubling the Federal expenditures for university basic research, and the five-year doubling of the NSF budget which you, Mr. Chairman, referred to, is a request for a 17 percent increase for 1988 which must be considered as a first and major step which achieves this goal.

This is needed to preserve our lead in science, engineering and technology, so that our industries can remain competitive internationally, and our standard of living can be maintained at home.

Where does NSF fit into this picture? The Foundation is the only Federal agency with broad responsibility for science and engineering basic research and education. NSF supports mathematics, science and engineering education at all levels of the educational pipeline, from pre-college all the way to graduate education, in ways that link education and research in a symbiotic way.

NSF encourages research on the boundaries between established disciplines where some of the most significant problems arise, as well as disciplinary research.

NSF encourages cooperation between universities and industry, and among Federal, state and local governments, in order to enhance the knowledge transfer between the source and point of use.

At the same time, we are leveraging the taxpayers' dollars.

Finally, NSF supports developing institutions and regions, undergraduate institutions, and broader participation by minorities and women.

In our 1988 budget submission, we have focused, and we are focusing, on four major strategic areas, and I want to quickly discuss each one.

The first one is the area of education and human resources. People are our most important resource. Reflecting this priority, our budget proposes a 50 percent increase for education and human resources. The Foundation has always been involved heavily in education efforts, but this year's proposal represents a strengthened commitment.

In 1983, the Science and Engineering Education Programs were approximately 1.5 percent of the Foundation's budget, a very low point.

In 1988, these programs will be about 6 percent of the total, and they will grow more rapidly than the rest of the Foundation as our budget doubles over the next five years. And they are only part of our overall human resources effort.

Just as important as programs is the linkage between education and research programs.

Why is this important? Because only tight connections between research and education can ensure that education remains relevant and up to date in the rapidly changing world of science and technology. Altogether, education and human resources activities will be over 14 percent of the total NSF budget in 1988.

The second area of strategic emphasis is Science and Technology Centers and groups. This is another important aspect of our proposals for 1988, and essentially what we are proposing is to increase this by about $80 million. There will be additional Engineering Research Centers and centers for biotechnology, materials science, and computer and information sciences, and others.

These centers are located at universities. They are multidisciplinary and are organized with strong industry involvement. They do basic research on problems that are important to science and important to competitiveness.

This is the program that the President announced recently in his State of the Union and referred to in his Quest for Excellence message to Congress.

These centers are also part of our strategy for developing human resources, because they involve both graduate and undergraduate students in research that is current in the industries in which they will soon find employment.

Finally, the movement of students to industry and of senior researchers in both directions is one of the most effective ways to move knowledge out of the laboratory and apply it in economically significant ways.

Our third focus area is investing in disciplinary research, disciplinary research in science and engineering. We need to continue to keep it growing and keep it healthy. It requires special facilities to support this effort, and NSF will assure that the right balance exists between it and the centers' groups in education and research in general.

Let me conclude, Mr. Chairman, by referring to the President's initiative to set the country on a new Quest for Excellence. He said that our initiatives and policies must have three goals. They must generate knowledge in science and technology. They must swiftly transfer that knowledge to the marketplace, and they must expand our nation's talent base in science and engineering.

These are objectives that will be met, in part, through the programs of the National Science Foundation. But they are long-term challenges. They will be met only by a long-term commitment to strengthen our science and engineering base.

The significance of the 1988 budget and the doubling of the Foundation's budget over the next five years is that it makes that particular commitment.

Thank you Mr. Chairman.

[The prepared statement of Mr. Bloch follows:]

ERICH BLOCH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Good morning. When I appeared before the Subcommittee on Science, Research and Technology two weeks ago I discussed the Foundation's 1988 budget proposals in the context of economic competitiveness.

I want to expand on that theme this morning, before getting to your questions. You already have our detailed budget proposals, so I will dispense with a more detailed statement for the record today.

Before that, however, I would like to congratulate you personally, Mr. Chairman, as you take over this committee.

Mr. Fuqua was a distinguished chairman and an important friend of American sicence and technology. Under his leadership the committee established a long record of support for basic science and engineering, and for science and engineering education. I know you will continue that record.

Appearing before this committee has always been a highlight of any NSF Director's activities, and I am sure it will continue to be so. We look foward to working with you on some of the most important questions that the nation will deal with in the coming years.

We have heard a great deal in recent months about the need for economic competitiveness. The debate is welcome: competitiveness is not just a buzzword. It is a concept and an idea of real significance for policy.

In my own view, it is about time that economic competitiveness moved onto center stage. For too long we have searched for sources of our economic problems outside our own boundaries, such as unfair trade practices, or low wages in other countries, or unfavorable exchange rates.

But recently we have realized that to compete successfully as a nation the most important thing is to do a better job than our competitors. It comes down to creating new and better products, manufacturing them efficiently, and getting them to the market first at competitive prices.

We can succeed if we look to our own resources, of which the most important are *new knowledge* and *well educated people*. These are the key elements of a competitive economy.

New knowledge, which we get through basic research, is important because it provides ideas for the new products that we need to compete in high-technology areas. It also helps us improve low-technology manufacturing and service industries.

Education is important because talented and well trained people are the source of the ideas, and the main resource needed to put them into practice.

New knowledge and education are prerequisites to economic strength.

Both ideas and people are produced in universities. That is why it is so important to increase investment in our universities. And that it the central idea behind the fiscal year 1988 budget request for the National Science Foundation.

Our request for fiscal 1988 is almost 1.9 billion dollars. That is nearly 17% above our appropriation for the current year. It reflects the importance that the administration has attached to basic research and education in science and engineering, particularly in our colleges and universities.

In addition to this request, the administration is committed to increases that will double our budget by 1992. This commitment is unusual, and important. It establishes a strong base from which to plan our future.

The increase is part of a national effort to increase support for university basic research. Only by doing so can we preserve our lead in science, engineering, and technology, so that our industries can remain competitive internationally, our standard of living be maintained at home, and our national defense be assured.

A competitive economy is one that can produce efficiently. In the years since World War II productivity increases have come primarily from new knowledge, in the form of technology.

But during the 1970's the United States neglected its research and engineering base, with the result that our trading partners have moved ahead of us in important industrial technologies as their investments in R and D and in education have increased.

As a consequence, the United States is now only fourth among the industrialized countries—behind Japan, West Germany, and France—in the fraction of gross national product invested in civilian research and development. Too few of our students are choosing science and engineering careers, and too few of those who do continue to the Ph.D.

That is not the way to stay competitive. Failure to invest adequately in R&D has far-reaching adverse consequences.

As a nation, we have begun to move to reverse these adverse trends. Much has been accomplished already. Despite this, however, the fraction of Federal R and D support that goes to universities has been dropping. Reversing that trend is a major objective of this budget.

The main responsibility for maintaining economic competitiveness rests with the private sector. Government's role is generally limited to such matters as trade, taxation, and antitrust.

But there is one area in which Government's role is critical: That is the support of basic research and education. This is a long term matter. Nothing we do here will produce quick results. But in the long term, nothing else we can do will have surer results.

Now, where does NSF fit into the picture?

Concern with the long term means concern with all parts of the science and engineering base. The Foundation is the only Federal agency with such broad responsibility for basic research and education.

NSF encourages research on the boundaries between established disciplines, where some of the most significant problems arise.

NSF supports mathematics, science and engineering education at all levels, and in ways that link education and research in a symbiotic manner.

NSF encourages cooperation between universities and industry, and among Federal, State, and local governments.

NSF supports developing institutions and regions, undergraduate institutions, and broader participation by minorities and women.

Education and the National Science Foundation

Let me turn for a minute to an issue that both the committee and the Foundation believe is of utmost importance—the role of the NSF in science and engineering education.

As you know one of the major themes in our FY 1988 budget request includes enhanced support for education and human resources.

People are our most important resource. Reflecting this priority, our budget proposes a 50% increase for education and human resources. The Foundation has always been involved heavily in education efforts, but this year's proposal represents a strengthened commitment.

Let me stress that word: "*Commitment.*"

In 1983 the science and engineering education programs were only 1.5% of the Foundation's budget—a low point.

In 1988 the SEE programs will be 6.1% of the total, and they will grow more rapidly than the rest of the Foundation as our budget doubles over the next five years. And they are only part of our human resources effort.

Just as important as commitment is the *linkage* between education and research programs.

Why is this linkage important? Because only tight connections between research and education can ensure that education remains relevant and up to date in the rapidly changing world of science, engineering, and technology. This is important in our universities. It is just as important at NSF.

In 1987 our education and human resources effort totals $182 million, of which 46% is spent through the research directorates. In 1988 the total will rise to $273 million, with 58% in the research directorates.

Altogether, education and human resources activities will be over 14% of the total NSF budget in 1988.

Science and Technology Centers and Groups

Another important aspect of our proposals for FY 1988 is support for science and technology centers and groups, which will receive an increase of $80 million.

There will be additional engineering research centers, and centers for biotechnology, materials science, computer and information sciences, and social and behavioral sciences.

These centers are located at universities. They are multidisciplinary, and are organized with strong industry involvement. They do basic research on problems that are important to science and important to competitiveness.

This is the program that the President announced in his State of the Union Address and featured in the draft Trade, Employment and Productivity Act submitted to Congress.

These centers are also part of our strategy for developing human resources, because they involve both graduate and undergraduate students in research that is current in the industries in which they will later find employment.

Finally, the movement of students to industry and of senior researchers in both directions is one of the most effective ways to move knowledge out of the laboratory and apply it in economically significant ways.

Investing in Basic Research

By its nature the research process cannot be planned. Not all projects deliver on their promises, and often the most significant insights come in unexpected ways. Nor can the technological or economic payoff be foreseen in many cases.

Nonetheless, history tells us that the payoffs are there, and are often dramatic. Faraday's investigation of magnetic fields—at the time little more than a curiosity—led directly to the electric motor and generator.

Maxwell's attempts to understand the relations among electricity, magnetism and light led first to radio, and eventually to modern telecommunications.

Roentgen was studying fluorescence when he discovered x-rays, which were immediately put to use in medicine.

These are classical examples today. Let me give you two with more recent payoffs:

First: Super-Conductivity

Super-conductivity is much in the news today, but it is a phenomenon with a long history. It was discovered in 1911, when scientists learned that certain metals lose all electrical resistance at temperatures a few degrees above absolute zero.

For a long time the practical applications were limited, because maintaining very low temperatures was expensive. But within the last month, researchers in industrial laboratories and at universities here, in China, and in Europe—which shows the international nature of science—have demonstrated that super-conductivity can exist at much higher temperatures—temperatures that can be achieved with inexpensive liquid nitrogen.

As a result, the cost of super-conducting may drop a hundred-fold and may revolutionize electric power generation and distribution, transportation systems, and computing.

Magnetic Resonance Imaging

The second example is magnetic resonance imaging. Magnetic resonance was discovered in the 1940's, but only in recent years has it been applied to medical imaging—in effect, to creating a replacement for x-rays.

The essential discovery was that a magnetic field is modified slightly as it passes through tissue, in ways that can be used to describe the structure of the tissue. Super-conductivity is required, to produce the necessary magnetic fields in compact instruments. And finally, mathematics first used by astronomers is used here to put many different images together in computerized axial tomography—the familiar CAT scan.

For patients the result is that a CAT scan can be done without the dangerous effects of large amounts of x-ray. For industry the result is a new product.

This is an example of the need for multidisciplinary research. The science and technology centers are an organizational tool to foster this approach.

Building Linkages Between Industry and Universities

These are all examples of basic research resulting eventually in important new technologies. But they all involved more delay than we would like—as much as half a century.

There is no easy way to change this. But part of the answer is to get the universities—where most of the basic research is done—in closer touch with industries that may use it.

Science and technology centers are one way to do this, and NSF is using some other approaches. They all come down to the same thing: the researchers need to know how industry looks at problems, and what industry sees as possible ways to advance.

Industry needs to know what university basic researchers are doing, what they consider important, what they consider possible.

Both sides need to pool money, talent, and equipment to work on interesting problems.

And people need to flow both ways in a steady stream, because knowledge is most easily transferred when the person who has it moves from one side to the other.

Mr. Chairman, the President announced recently a major initiative to set the United States on "a quest for excellence".

He said that our policies must serve three objectives:

They must generate new knowledge in science and technology;

They must swiftly transfer that knowledge to the marketplace; and

They must expand our nation's talent base in science and engineering.

These are objectives that will be met, in part, through the programs of the National Science Foundation. But they are long term challenges. They will be met only by a long term commitment to strengthen our science and engineering base.

The Foundation's FY 1988 budget request and the commitment to double the budget over five years are a concrete start on this commitment. I urge the Congress to join together with the Administration to make this commitment real.

Mr. Roe. Thank you, Mr. Bloch, for your testimony.

May I say that I feel excited about your testimony, because I read your in-depth presentation, because I think that you're right on target in many, many areas, and you have the courage to speak out.

However, let me be the devil's advocate a little bit this morning. Here we are sitting with a $200 billion, plus or minus, deficit, and we have an enormous confrontation taking place on the budget issues. And, of course, all Members of Congress, or the House at least—and I'm sure, the Senate—with their individual responsibilities, who all kind of come back and say, "Well, we know we have to reduce that budget level, and we've got to do something to work towards a better financial situation," and you come in rather uniquely, because you now are recommending increasing the budget, and there are some forces that are coming back and saying, "Well, why should we do this?"

And the point of my focus is, when we speak about this budget issue—and this Committee has to authorize, as you know, at the proper levels—why should we do that?

Members of this Committee think there are certain areas, the focal point being on the overall budget per se, so why should we be budget-busting, and why should you ask us to budget-bust on this?

Mr. Bloch. Well, that's a question——

Mr. Roe. That's a big question, and I'm looking for a broader answer.

Mr. Bloch. That has been asked from time to time by other Committees.

Let me start from the following viewpoint. Even in a very constrained environment, constrained budgetary environment, I think it's very important that one sets priorities. Not everything can be treated the same way, because certain things are more important for the long term, certain things are more important for the short term and so forth. So even in a constrained environment, priorities have to be set.

The second thing is that we have to look at the future and ask ourselves, "How do we get out of this deficit situation? What is it that can get us out of it?"

And as Mr. Boehlert mentioned before, it's not by closing ourselves off from the rest of the world and not letting any foreign products in. It's essentially trying to become better ourselves, more competitive ourselves. In light of that one point that I made in my opening statement, what can get us there? What can get us there is new knowledge, a new knowledge base, and people. We are always depending on people, obviously, educated people, people who know what goes on at the forefront of technology, at the forefront of manufacturing, at the forefront of science and engineering.

If you take that kind of an approach of trying to get out of this deficit situation that we are in, then I think we have to look for the remedies that will get us out of there. And I think what the National Science Foundation represents—knowledge creation, knowledge generation, transferring that knowledge into the marketplace via the private sector, and educating people at the same time—I think it's one recipe for getting us out of this predicament.

So I would say, looking at the long term, I hope everybody will be convinced that that is the right approach.

Mr. Roe. Let me ask you this. Suppose for the sake of discussion that you are sitting on this side of the table, and you had to meet that budget problem, and the Committee were to come back and say to you, "Well, Mr. Bloch, we think you have done an excellent job, and you're a very, very forthright, upfront, advanced thinker," which we believe, "very responsible in your work, but in spite of all of our affection and respect for you, we just don't have this much funding available," and you cover a whole plethora of issues. You spoke to competitiveness; you spoke to education, and you spoke to the transfer of R&D and the balancing of the R&D program and seeking a better balance.

But suppose we said to you, "Well, we appreciate that, but we've got to cut $400 million out of your budget," and suppose you were to have the opportunity to choose where that would come from—and I'm not being facetious—where would you choose?

Suppose you are faced with that problem, and I am, by the way?

Mr. Bloch. Well, I hope that is more or less a hypothetical question, but——

Mr. Roe. There's a certain amount of reality to it right now.

Mr. Bloch. But let me answer it as straightforwardly as I can. Obviously, I can't give you numbers and line items, but let me just paint a picture for you.

First of all, let me say one thing. This budget that we put together for 1988, just like previous years' budgets, is a well-balanced budget. The priorities have been set; the priorities have been put in place. Not everybody got the same increase, to the consternation of a few disciplines, I must say. Also, we have focused on the balance between education and research, between multidisciplinary research, individual research, and so forth.

So I consider the budget approach that we have taken and the budget that has resulted from it to be a well-balanced kind of a budget, and I would not like to destroy that balance, regardless of the absolute number of dollars that we have available.

I think what you are going to see, probably, if we are faced with the kind of a draconian measure that you are indicating, is that we would preserve that priority. The first thing that we would try to preserve, as much as possible, without being able to say right now that it will be 100 percent preserved (I don't think I can make that statement, and I don't expect--and I don't think you expect me to make that statement) that we would preserve some of the education and new resources areas in a very dramatic kind of a way. We would give that priority over everything else. That is pre-college education, undergraduate education, graduate fellowships, some of the minorities and women's programs that we have. It's also materials development in pre-college and materials development in undergraduate areas and so forth. We can essentially keep these areas in place as a high-priority item.

We would still continue moving in the centers direction. I think that's very important. We wouldn't have as many centers, obviously, as we are planning on doing today, but they come in incremental jumps anyway. We can have five centers or 50 centers. We can have three centers or six centers in certain areas. So we would cut down dramatically in the centers areas, the number of centers we are creating, but we wouldn't give up on that priority.

And last but not least, we would have to sacrifice some of the things in the disciplinary areas. In the disciplinary areas, we have been focusing on the size of the grant, because that is suboptimal as it exists today. It doesn't buy what it's supposed to buy in terms of instrumentation and in terms of support to graduate students, as examples.

We probably would not move in that direction. We would leave it at the level where it is today and maybe even have to cut some of the number of disciplinary individual grants from the ones that are planned.

So that would be my answer.

Mr. ROE. Would such a cut, would that, in your judgment, would that materially reduce the initiative and the thrust you are trying to make where competitiveness is involved and high-level research?

Mr. BLOCH. Sure.

Mr. ROE. Let me ask you the antithesis of that question. Suppose we were to come back and say to you, "Well, all right, you've made a good case, and we've studied this out carefully, and we think what you're doing is right, but we think that"—if you had the opportunity to increase your request, what areas would you focus on?

Mr. BLOCH. That's a lot easier to answer.

Mr. ROE. I thought it would be. [Laughter.]

Mr. BLOCH. And obviously what we would do with an increase is focus on—an increase over our request, I want to say—is focus on some of the areas that we probably have shortchanged somewhat.

Mr. ROE. Where would they be?

Mr. BLOCH. We certainly have shortchanged some of the pre-college education areas very clearly. We probably have shortchanged some of the instrumentation areas throughout our efforts, not just concentrated in one area. I think we have probably shortchanged some of the disciplinary areas, if you look at them item by item or area by area.

So I think we would focus on education, on the disciplinary areas, and on some of the infrastructure problems like instrumentation, as an example.

Mr. Roe. Well, that's where I wanted to lead to. I think you've given a good response.

Where we're coming from, I happen to think, as Chairman of this Committee, that this particular area is one of the most important areas we have to deal with, because this is the very fundamental foundation of the future economic dynamics of this country, in my judgment, and I believe that to be so.

And the question is, when we're going to be expending funds, what we're saying to ourselves—and I think you are saying to this Committee—that we realize that you, Members of the Committee, and from all across the nation have great responsibilities, but all that notwithstanding, there ought to be priorities within priorities, and the idea of cutting across the budget, and we'll just whack out 3 percent here or 4 percent there or 5 percent there is sheer lunacy, as far as this country is concerned, as far as this government is concerned.

There are certain basic areas that, if we are to regrasp the opportunity and the thrust and the challenge in the innovative field and the high tech field to be able to be competitive and to provide the job opportunities and the future dynamics economically in the country, we've got to know where to spend our money.

That's the point I wanted to—and you did a good job in getting to that.

Now that gets to the point of further expansion. Now it seems to me that when we're talking about legislation—I'm taking much more time than I meant to, but I think it's important here this morning—for example, I believe that there's got to be a greater thrust made in the quality of American education in the field of science and technology. From all the work that we've been doing over the years, I just don't believe that we're devoting enough resources that are specifically directed in the lower levels of education, in the grammar school level up to the high school level, because by the time that we get to that point and we're putting money into high schools or into universities, we've already killed off the incentive of the kids coming along.

It seems to me, when you look at the Japanese system of education, when you look at what the Soviets are doing and others, they are concentrating on first grade, and they're teaching their kids science and technology, and it's part of their way of life. So if we're looking for those opportunities, no more service—or all service jobs, not enough technical jobs—do you believe that we should be devoting resources into the lower school grades, at first grade, and having a basic program nationally that begins to direct our attention to this area?

Mr. Bloch. Well, to answer your question directly, yes, we need to do that. And by the way, the Foundation has directed its effort at the pre-college area in our Science and Engineering Education Directorate. In fact, that's how we reconstituted that directorate, by focusing entirely during the first three years at the pre-college areas.

So I think we definitely need to do that, and we probably need to do more than——

Mr. Roe. Would the gentleman yield?

You speak to pre-college. That muddies my waters a bit. When we speak to pre-college, that can mean a lot of things. I want to get specifically to the point of getting down to first grade.

Mr. BLOCH. When I say "pre-college," I mean that. I mean that you go from kindergarten through high school.

Mr. ROE. Okay. All right. But what do you see in the dynamics—and excuse me, if I'm interrupting—but what do you see in the dynamics?

People say to me, "Well, you know, Bob Roe, you've got good ideas there, but that's the mores of the tribe. It will take generations to get to the point," and I say, "Balderdash." If I were the Governor of a state, I would call in my Director, my cabinet officer in charge of education, and I would say to him, "By next week, I want a program ready to be put through the State of New Jersey where we start science and technology and arithmetic and the basics in first grade."

And you know what he would do? He would either go out and start that program, or he wouldn't be Commissioner of Education very long in the State of New Jersey.

So I don't believe in this point of view that seems to come from some facets of the academic community, where they come back and say, "It will take time. It will be the mores of the tribe." I say that's just—I can't say it; there are ladies in the rooms, but, you know, it's just not—it's not so.

Now what is your feeling towards that? Do you think we're doing enough in this area? Do you have any strong ideas or feelings?

Mr. BLOCH. No, we are certainly not doing enough in this area, and I——

Mr. ROE. If anything.

Mr. BLOCH. And I don't believe that it's a cultural problem necessarily, and that it takes centuries to change that.

On the other hand, there is something to that, that it needs to be supported by the home, essentially. It needs to be supported by good teachers. It's not just that you can put the teacher in front of the class that doesn't understand that there's a problem.

Mr. ROE. Oh, we're in complete accord there. Teachers can't——

Mr. BLOCH. And all of that. It has to touch many different areas, is my point.

Mr. ROE. Yes, I agree. But there doesn't seem to be enough emphasis placed on that. I mean, when we look at the National Science Foundation budget—and if I seem to be pedantic or a little critical, I'm not meaning to be critical in that sense; if I was, I would say so, or if I were, I would say so—where I'm coming from, we've got to—you're making some fundamental recommendations here above budget levels, which this member supports very strongly, and I intend to use the full effort of this office, both in help and cajoling and everything, and win the support of our colleagues to say that the future of our country depends on what decisions we make now, four years down the road.

But I don't hear anybody coming back—they speak about more money for education. That's like more money that goes in water resources, unless it goes someplace that makes a difference.

Now we say the home and so forth. We're not retraining our teachers. I don't know whether we have enough teachers in this country right now trained to be able to teach basic science. Am I right, or am I wrong?

Mr. Bloch. Well, that's right.

Mr. Roe. Well, why don't we do something about it?

Mr. Bloch. Well, let me——

Mr. Boehlert. Mr. Chairman, may I just interject one point here?

Mr. Roe. Yes.

Mr. Boehlert. It's a very important line of questioning.

The typical high school science teacher in far too many of our high schools across America was trained to teach history, not science. The exceptional math teacher is not in our high school; that exceptional teacher is in industry.

So with the Chairman's line of questioning, I couldn't agree more, and I share his concern, and I'm anxious to hear your response.

Mr. Bloch. Well, let me make a few comments on that.

First of all, I agree fully that we have to focus on what I call pre-college, and which we agreed means kindergarten through high school essentially. We need to focus on that area.

If you look at the National Science Foundation budget, we are focusing on that area. You can say we are not focusing enough on it, and that's a fair criticism.

But we also have to focus on the total pipeline problem, and that's the National Science Foundation's other problem. It's not just pre-college. It's also on the graduate education, which is not the best anymore in this country. And it's also undergraduate education.

So what you are seeing essentially in our budget is a mix of these three areas that are being addressed and hopefully addressed with quality programs.

Dr. Moore. Mr. Chairman, if I could just make a comment in connection with that. As you know, a major part of the activities of the SEE Directorate is in teacher preparation and enhancement, and these programs are designed to improve the quality of teaching of science and math in the pre-college levels.

But you are focusing a lot on the elementary school levels, particularly the first grade——

Mr. Roe. I've only begun to ask my questions, and I've taken more time from my Members than I should, but the Chairman has that prerogative once in awhile.

Dr. Moore. Let me just make one comment. The Directorate has just awarded three contracts to consortia to develop curricular materials designed for the K-through-6 grade levels, so this is an area where we are with you in believing that there is a serious problem to be addressed, and we're making a start in that direction.

Is it enough? No, it's not enough, but we recognize that there is a problem there.

Mr. Roe. Well, I've already taken more time, and I appreciate your response.

Where I'm coming from is twofold. One, we have a process to go through, and this Committee is going to have to stand up loud and strong and tall to retain what you're doing.

I happen to think that your particular function, the National Science Foundation, is the cutting edge right now of what direction this country takes in this whole competitiveness buzzword.

Be that as it may, I don't think you've asked for enough help in this area, and the Committee is going to direct its attention to that.

The second point that I see is that I'm very much concerned about the infrastructure situation in our universities and our colleges. Now they're coming back to us—and believe me, I'm not a novice in this field; I've been into it in depth—and they come back and they say to me, "Well, we're not getting as much teaching materials in the way of high instrumentation and so forth. You've got a tax bill that passed, and we haven't figured that out yet. We're not quite sure what that means to private industry and how much they can either write off, and then they do give us stuff that's kind of antiquated," and blah-blah-blah and the whole bit. You listen to that jazz.

And I come back to them and I say, "Well, what are you doing about that? How can you—if you don't have any pencils and books, how are you going to teach the students? What do you use?"

Well, we're trying to get that going, and I don't see anything that you've asked for here that talks about that infrastructure.

When Sputnik went to the—you know, off into space and so forth, the educational budget and the need for resources and starting to get back to teaching in lower grades—pre-college, you'll pardon my—if I don't use the right euphemisms here—the pre-college age and so on and so forth—and my God, the budget went way up because people said, "Hey, they're ahead of us."

That situation is no different today from an economic point of view than it was at that point.

But you haven't asked for anything. We're coming back and saying—in fact, I'm planning on putting in legislation myself, and I'm going to ask the Members of this Committee to join with me and start to foment an infrastructure program for the universities. You can't teach if you don't have the tools. You can't teach if you don't have the trained teachers. You can't teach if you don't set a curriculum in first grade.

And I'm not coming down hard on you, because I think you're champions of the cause. What I'm coming back and saying is, I think this committee has to be bold and set those particular dimensions, if we're to move ahead.

Does that make sense to you, Mr. Bloch?

Mr. Bloch. Yes. That makes a lot of sense.

Let me just say one thing, that many of our programs are addressing that infrastructure that you are talking about, programs in instrumentation for colleges, not just for research, but for instructional laboratories in four-year colleges, as an example.

Many of our programs are attacking the instrumentation question which you just brought up. Many of our programs obviously have to do with facilities in one form or another, special kinds of facilities for research.

So a lot of our dollars are linked into what you mentioned and defined as infrastructure. Fellowships are infrastructure, in essence.

Mr. Roe. Human infrastructure.

Mr. BLOCH. Human infrastructure.

Mr. ROE. All right. I thank you for your indulgence.

The Chair recognizes the distinguished gentleman from New York.

Mr. BOEHLERT. Thank you, Mr. Chairman. I could go on all day on that line of questioning because I happen to agree with it wholeheartedly, and I'd be glad to work with you as we develop your initiative.

Mr. Bloch, as you now are vitally interested in our supercomputer initiative, I'd like to know just where you think we are right now with respect to the Phase II centers?

Mr. BLOCH. Well, I think the Phase II centers are in existence and they are healthy, or getting healthier. Let me put it that way.

Mr. BOEHLERT. Would they give me that same response to the question? Do they—are you fulfilling your commitment to the Phase II centers?

Mr. BLOCH. I think we are fulfilling our commitment. Now let me just recite for a minute where we are with regard to these supercomputer centers.

As you know there are 5 of them in existence. That's about all we are going to establish at this time, and probably for the foreseeable future. That's different from our original plan, which added—which contemplated more centers, but in the meantime other—other universities have been able to establish supercomputer centers, so that we don't see the tremendous amount of capability—of capacity that was required at one time in front of us.

With regard to the 5 centers, the first one that I want to mention is Illinois. We had a program with Illinois starting in 1985 through 1989 on a yearly basis. We have done exactly what we said we would do. In 1985—we allocated $5.1 million. We planned on $5.1 million, they got $5 million. In 1986, we allocated $7.2 million, they got $7 million. In 1987, $8.5 million, they got $8.5 million. Now what's—what's happening if you—now let me take—stick with Illinois for one second because it's kind of an interesting center.

If you ask the center director if he's satisfied, he'll tell you no. And he'll tell you no for a couple of reasons. First of all, he has seen the need for additional resources that he does not have, and that we never allocated to him, and never promised him, like for instance, extensive graphics capabilities, and as you know, this is a fast-moving kind of a field, and we'll—and we have to make do with what we have.

Could he use more money in an effective way? Absolutely he could, and I would support it if we had the money, but we stuck to our—to our original plan, and I think it has—it has worked out very well as far as that original plan is concerned.

You mentioned a second one—the supercomputer center at Pittsburgh. It got started in 1986. It was a very rapidly moving kind of a center. We promised—we had an agreement with them—a plan, for $2 million and $4 million for 1986 and 1987 respectively, and that's what they received.

The San Diego supercomputer center: We had a plan for $5 million—$4.9 million in 1985, $9.5 in 1986, $12.1 in 1987. They got $4.7 in 1985, $9.1 in 1986, $11.5 in 1987, and there are minor differences between the plan and adjustment, like a 5% kind of an effect which was done because things moved around a little bit, not because we wanted to cut—cut the center.

The John Von Neumann center in Princeton is a little bit of a different story. We had a plan that would have built up that center at a much more rapid rate than it has been building up, no doubt about it. But the machine that we are counting on, and which still has not been delivered, which is late in delivery, and will probably slip further, is the cause of the—of the funding of that center not being commensurate with the plan, no doubt about it.

What we have done with that center in the meantime, however, because of the slippage, we have convinced the manufacturer to help us out in the meantime, and he has made free time available on existing machines, Cyber 205 machines. So the center is operating, but it's not operating to the fullest where it should be operating because the machine is not available, and I regret that as much as anybody. But that—that's a fact.

The Cornell supercomputer center has been fairly well on target, maybe 10% under—under the target in 1987, $5.2 versus $6 million and that has to do with essentially again, they are—they are coming to grips with some of their problems in a slower way than—than we anticipated. So I think, yes we have had—we operated the centers the way we wanted—we said we would. We made available the dollars within—within the reality of the situation, and with the reality——

Mr. BOEHLERT. Mr. Bloch, has your thinking changed with respect to funding for the Phase I centers?

Mr. BLOCH. No. My thinking hasn't changed at all with regard to that—to the Phase I centers. The Phase I centers, we said we would phase out when the Phase II centers would be in existence, and we have done exactly that. With the exception of $1.5 million in 1987 in one center, namely the University of Minnesota, we are not spending any more money on Phase I centers.

Mr. BOEHLERT. My time is up, but I'll be back to you.

Mr. ROE. Why is that decision made? Because the people from—the members from Minnesota have raised that question rather strongly with me. They feel there's an expertise. I'm thinking now specifically of Minnesota. They figure there's a great expertise there, they did a lot of good work in foundation and now they're out. Are they out because of financial resources, or are they out for any other reason?

Mr. BLOCH. Well, that's a long history on Minnesota. Minnesota submitted a proposal in response to our Phase II solicitation in 1985, and they didn't make the grade. Very simple. The other 5 centers got higher marks on the competition.

Mr. ROE. Why 5? Why wasn't it 9?

Mr. BLOCH. We didn't have any money for 9 centers.

Mr. ROE. That's what I'm saying. You just didn't have the funding?

Mr. BLOCH. That's right. The cutoff had nothing to do with the quality of the submission. The cutoff had to do with the availability of funds that we had available. Very simple.

Mr. ROE. Well, in your judgment, if we had all the money in the world and we were printing it, would you have—would you think that we need more centers?

Mr. BLOCH. Well, that's a comment I made before. If you had asked me—by the way, we had a plan of something like 10 centers that we wanted to establish over time. I think I'll—I had changed my mind today and would not make that kind of—putting out that kind of a goal in front of us, because as I said before, a lot of other centers have come into existence, and supercomputer capacity and capabilities in the universities today are different than when we started the centers.

The center in Florida has opened up, and the Minnesota center that you mentioned. There was already one in Purdue at the time we opened up. There's a new supercomputer center just going in in Michigan, a new supercomputer center in Michigan. There is one in the Houston area—on and on. There are a large number of centers being established without the support from the National Science Foundation. Sometimes it is with the support of the Federal Government, but not exclusively. Many times it is with the support between the university itself, the manufacturers and the states. So I think we were the catalyst, and I—at least I claim that we were the catalyst for these—for these centers, and in the meantime all the centers have come up and we have turned away from increasing the number of our centers as a consequence of it.

What we are focusing on, which is equally important, or maybe even more important in the end, is the networking of all of these centers, so that the whole university community can have access to the centers regardless of where you live and where you work geographically speaking. And that is very important to us, and very important to the community.

Mr. ROE. The Chair recognizes the gentleman from Pennsylvania, Mr. Walgren.

Mr. WALGREN. Thank you, Mr. Chairman.

Mr. Bloch, the—certainly it would not be controversial to say that if we are to develop strongly in the future we have to increase our productivity and the way you increase productivity is you—you produce more per manhour of effort, and I'm sure it's not controversial to say that given the potential of the application of the computer to manufacturing that we are on the watershed of a change in the nature of work, the likes of which we have never seen before, and one that will make the near term future very, very different from what the present is when it comes to the kind of work. If the United States is not the first to—to move in that direction, we will really be on the outside looking in, in my view, and I'm sure that of many others.

In 1984, the President at Carnegie Mellon University wrote a little article that tried to break out programmable automated research in the area of manufacturing on the Federal level, and essentially he found $80 million, of which $63 million was funded by the military, and the military was very specific in their areas, but not necessarily generally applicable. In the National Science Foundation he found a total of $7 million in 1984. Can you tell us what kind of an effort are we making in programmable automated manufacturing in hopes of staying abreast of that change?

Mr. BLOCH. Yes I'd be glad to comment on that, Mr. Walgren.

First of all, this concept of programmable manufacturing has—has broadened since 1984 in a significant kind of a way. Many of the things that—that today are being talked about in different languages fall under that program. It's not just computers and automation. Robotics is a programmable manufacturing technology. It's a whole area of software for manufacturing, inventory control and so forth. It is obviously programmable.

We have pulled together within the Foundation all the expenditures that we have in the manufacturing sector, and most of—that apply to manufacturing research I should say, and most of these things you could very much accommodate under this program—the programmable manufacturing banner, and our 1987 estimate of what we are spending was about $46 million. Our 1988 estimate is about $50 million. Now things that are included in here are programs that are based in—in—in the Engineering Directorate, as well as in the newly formed Computer and Information Science and Engineering Directorate. Let me just give you a little bit of a feel for it. For instance, in one area dynamic systems and controls is one major activity. Another one is systems theory and operations research. In a third area it's design theory and methodology—manufacturing systems. Automation and systems integration is another program. Computational engineering obviously falls into these areas. Information, robotics, and intelligent systems are included in here and last but not least there are—there are many areas of the SBIR programs, the Small Business Innovation Research program, that falls—falls into this category. So I think we have a very broad activity in this particular area.

Mr. WALGREN. Let me raise one concern, and that is that I fully appreciate the importance of the centers, and I realize that they are new initiatives, and that they are a direction that is bringing the multidisciplinary fermentation, but at the same time, I think it's—it's important to have a real strategy that—that makes sure that individual research investigator grants are not underemphasized, and I have noticed in the—in this area about one quarter of your effort would be in the centers. Now I don't know whether that's too much or too little, I just want to make the point that we ought to be looking at that, and I hope as management in the Foundation you will really be examining yourselves on that point.

If I might, I would raise one other question that also has to do with geographic distribution. We're all seeing now in the paper about the new superconductivity efforts and realizing that in the Wall Street Journal of Friday, March 20, Japan is racing to commercialize superconductivity technology while the United States is saying, well it's probably too early to do anything. If history is any lesson, I think that response of—of not mobilizing in an area that has such potential as this, is probably wrong.

But my point is this—that as I understand that research was done at 3 separate universities, none of which was a major university—major research universities that we think of in the classic sense, and another concern out of that is someone anecdotally told me that every researcher involved in that project was a—was not an American educated national. Now I don't know the truth of that, but apparently very broad participation by what is becoming commonplace in our system, that we don't have Americans coming through our educational system, but are rather having to rely on imports from the rest of the world.

My point is, is that here is an example of the value of diversification in terms of the geographic distribution and involvement of these non-major research universities, and—and a tremendous example of the—the over-reliance we are now forced to make on individuals that come to us from abroad at one stage in their life or another.

Mr. BLOCH. Can I comment on your points?

Mr. WALGREN. Appreciate it.

Mr. BLOCH. First of all, let me take that example of room temperature superconductivity which is an exaggeration, by the way, but not that much, and make a couple of other points on it, not only that it involved, as you correctly pointed out, some of the lesser known research universities in this country. Houston and—Houston and Alabama in particular, but also it involved—it was an international kind of an effort because there were at the same time discoveries made that moved in exactly the same direction in China as well as in Switzerland. By the way, the Switzerland discovery had to do with a—with an industrial laboratory, in the—an IBM laboratory in Zurich. So it was an international effort, to make your point.

The second point you are making is essentially on our dependence on graduate students, and especially Ph.D. candidates from abroad. That's a concern that we all should have, not that that is bad, as long as these people stay in this country, and there are a big portion of them staying here, but we can't depend on that. We can't even depend on the fact that they come here, we can't depend on the fact that they will stay here as capabilities develop overseas in their own countries, more and more so. So I think that's what—what I consider to be a very serious problem. We have focused on—on that area in terms of our graduate fellowship programs, and in terms of——

Mr. ROE. Will the gentleman yield? Get back to that point. And that gets back to my earlier point. Why is it that we don't—we have that problem? I for one believe that minds are human computers, and whether they're born in Germany or England or wherever, it really doesn't make that much difference.

On the other hand, I think the point the gentleman is making, that's one that's raised quite frequently, that in many of our advanced graduate program we have people from other countries kind of leading the way. Now the question is why are there not more native born people in that area? What's the disparity there?

Mr. BLOCH. Well, I don't think there is one—one simple reason for that. It's——

Mr. ROE. Well, there's got to be some reason for it.

Mr. BLOCH. Well there are a number of reasons for it, and let me try to—let me try to—to enumerate—for you. First of all, it must be said that in those areas where we have seen a major drop off of—of U.S. citizens participating in Ph.D. programs, it's in areas where there is a tremendous industrial capability and also attraction—computer science as an example. So a lot of people prematurely leave the universities and leave their studies to go into industry. So that—that's certainly one reason.

The second reason probably has to do with the value system that we have created here. It's—it's—I think if you look out economically, over your—over your future, and over your career, other careers are more attractive than becoming a scientist or an engineer. Just think of law, or think of—of business management. That's where the big payoffs are, so I think we have put a cultural system in place and a value system in place that hurts us in this—in this regard.

The third one is one you—what you focused on, Mr. Chairman, namely the preparation before you even get into college. A lot of people are turned off before they ever get into college. Therefore many of our—of our good minds that would—if that were not the case, probably have gone on for a Ph.D. in science and engineering, are not—not able to do so because they didn't get the prerequisites before they entered college. And there are probably other reasons besides those.

Mr. **Roe**. The gentleman from—Doctor, did you want to add?

Dr. **Moore**. If I could just add one comment. I think what Mr. Bloch has just been saying, and the points that have been made here illustrate the importance of something that was said earlier in the hearing and that is, that we're looking at a problem that in terms of personnel exists all along that pipeline, and we need to focus our efforts—I shouldn't say focus our efforts, I should say we need to pay attention to what it is that attracts people into science and engineering at various points in the pipeline. Mr. Bloch mentioned the problem that some students are turned off in their—early in their pre-college educations. That's one point that we—we think is important. But we also think it's important to make careers in science and engineering more attractive so that people will come into them, and we can make some effort to change this particular cultural phenomenon that he's—that he mentioned.

Mr. **Roe**. The gentleman from Pennsylvania.

Mr. **Walgren**. My time has expired, Mr. Chairman. I have no other questions.

Mr. **Roe**. The Chair recognizes the gentleman from Colorado, Mr. Hefley.

Mr. **Hefley**. No questions.

Mr. **Roe**. Mr. Skaggs from Colorado.

Mr. **Skaggs**. Thank you, Mr. Chairman.

Mr. Bloch, I was at a happy event yesterday in Boulder in which the announcement was made of the grant for the optical electronic computing center, and I wanted to express our appreciation for your support there. If we could only get you to add C.S.U. as a supercomputer center we'll be in great shape. [Laughter.]

Mr. **Roe**. No lobbying here. [Laughter.]

Mr. **Skaggs**. Pardon me, Mr. Chairman.

Mr. **Roe**. No lobbying. [Laughter.]

Mr. **Skaggs**. We're going to be having hearings in a couple of weeks, and I'm a new member of the Committee so was not able to sit in on your Subcommittee testimony earlier—hearings in a couple of weeks on the SSC project. One of the things I'm hearing from people in science in my district is a level of concern that that project, if it goes forward, is going to force out support for small science.

Your budget submission seems to contradict that fairly dramatically. But I'm just wondering if you could elaborate a little bit on how you see that playing out in the next few years, and the level of commitment you sense in the Administration to your budget and the support for—the terms happens to be smaller projects.

Mr. Bloch. Well, I think that's a very, very good question, and by the way, it comes back to Mr. Walgren's point of balance between individual investigators and centers in that regard. There is a similar balance problem here.

I just wanted to say that if—if you've followed what has happened to the National Science Foundation's budget and to the SSC decision, they followed in sequence. The first announcement by the President had to do with the doubling of the National Science Foundation's budget, and that was in realization that you can't undertake programs like the SSC without having your—your bases built and in place.

And the bases is essentially what we are supplying from the National Science Foundation, not exclusively, but to a great extent, people, the infrastructure that we talked about, and—and—and the grand mechanism that we have in place. So I think the priorities that the President has set are very clear and I agree with those priorities. Go fix up as much as you can, and you can't completely fix up, first of all, the base on which everything depends.

And that's what—what is represented by the National Science Foundation, and then in addition to that, I think we need something like an SSC. No doubt about it. It's the future of—of a big part of science, and it's a—it's a needed kind of a tool, and a needed kind of a facility that will be greatly used. But I think the priorities that the President set are exactly the right ones.

We need to put the base in place, we've got to make sure we've got the—we've got people who can use an SSC. If you don't have the people, there's not much use in building an SSC. You've got to have the science in place that allows you to use an SSC and explore new approaches and new discoveries, and that science is mathematics and chemistry and physics and everything else. So I think the priorities that you see are the right ones.

Mr. Skaggs. Thank you. I noticed in the budget summary shifting subjects, a move of the research component under science and engineering education from one category coupled with materials development and informal science down to the studies and program assessment line.

Is there a policy implication to that or is that just a more efficient way of managing your budget?

Mr. Bloch. Dr. Moore would like to answer that question.

Dr. Moore. Well, I think—it does not reflect a change in policy. We think that is a very important area for the Foundation to be working in. The change was made because, for managerial purposes, that seemed a more efficient way to handle that particular program.

Mr. Skaggs. Thank you. Thank you, Mr. Chairman.

Mr. Walgren [presiding]. Thank you. The Chair recognizes the gentleman from California, Mr. Packard.

Mr. Packard. Thank you, Mr. Chairman. It's nice to have you with us, Mr. Bloch.

Regarding the SSC, with the emergence of perhaps some new superconducting technology approaching; or which has the potential of approaching room temperature, your statement indicates that this technology could reduce costs by hundredfold.

Does it also have the potential of reducing the size or the scope of the project or will it still require a ring approaching 40 miles?

Mr. BLOCH. Well, I'm no expert in that area. By the way, I didn't indicate in my statement that it would reduce the SSC hundredfold. I was focusing on some applications that one can consider, that material could be applied to.

I want to caution a little bit. You know, a discovery in the laboratory, no matter how important it is, and that particular discovery is very important and would have long reaching consequences, it takes many years for that discovery to essentially yield a material that then can be applied for the right applications.

You have to make wire out of it. You have to be able to draw the wire. The wire has to have certain capabilities, current carrying capabilities and so forth. These are not small problems.

One has to be very careful that one doesn't overstate the case as to the imminency of applying a new discovery.

Now, in the case of the SSC, what I would think in probably a very naive way because as I said before, I'm not an expert in this area, far from it, that it would behoove those people who are responsible for the design of the SSC, that they keep that development in mind, that they probably cannot depend on it to be applicable to that particular design at a certain point in time, when it needs to be applicable.

I think you can make some provisions for it, that you can use it later on and improve the capability of that machine. I would look at it essentially in that sense rather than it turning that whole program upside down. I don't think it will do that or that it necessarily affords you a capability at a tenth of the cost tomorrow morning. I don't believe that will do that either.

Mr. PACKARD. It certainly does present us though with a dilemma because we are talking about a very expensive piece of research and it's a long term project. It isn't something that is going to be implemented within the next 2 or 5 years. We are looking down the road a decade or more before completion.

Well, to put that kind of investment into something that could be changed because of new technology and even though that technology may still be a long term technology, we are talking about also a long term project and particularly with the expense we are talking about, it does place a dilemma on the pace and commitment that we give to the SSC as it is currently considered or currently designed.

Mr. BLOCH. Yes, I think, Mr. Packard, this Committee and you yourself and the other members of the Committee deserve a very considered judgment of what the impact of this discovery is on the SSC. I just want to warn you and say just because you saw something in the laboratory two weeks ago, doesn't mean you can apply it tomorrow morning on a grand scale.

Mr. PACKARD. I understand that.

Mr. BLOCH. And even 10 years is not a long time to develop new materials and materials that are demanded in terms of their applications. You deserve a considered judgment. If I were you, I would ask for that judgment.

Mr. PACKARD. If in fact the new technology that—the new discoveries that have been made cannot be retrofitted to an existing or an SSC program that has been developed, then of course, we are looking at obsolescence or potential obsolescence before we even complete the project.

Those are the dilemmas we struggle with and I'm aware that it may not be that way.

A question on the supercomputer centers. In your budget, have you included funds, adequate funds, for upgrading and improving the centers or are we shifting more and more of those costs and the ongoing costs that universities are having to match, are we shifting more and more of the costs to the university or are we keeping pace as our Federal commitment?

Mr. BLOCH. No. Our commitment is to keep these centers at the leading edge of that particular technology and as you know, that technology is moving at a rapid rate. We have to upgrade and sometimes change the computers in those centers on a regular basis. That is included in our projection of what we are going to spend in those centers and when we are going to spend it. Upgrading is one of the very important parameters that we have taken into consideration.

Mr. PACKARD. One of the centers, of course, as you have already mentioned, is in San Diego, where I come from, and I've been to that center. It's a very good one and very well done.

There is certainly a problem and a concern that the universities are having to sustain a matching portion that is burdensome to the point where it is inhibiting their ability to move forward. Is there a solution to that?

Mr. BLOCH. Well, let me say the following. If you say matching portion, yes, all of these centers when they were established were asked to see what they could do in order to help reduce the cost to the Federal Government. Many of the centers got matching funds and matching activities from the manufacturers themselves, manufacturers of the computers. Some of them got it from the state. Some of them got it from the universities, but that was all figured in.

In all fairness, we are paying 60 cents on the dollar in all five centers. If you add all the five centers——

Mr. PACKARD. Our budget down the road keeps that same ratio?

Mr. BLOCH. Well, we hope—not necessarily exactly the same way, but we hope as new machines get developed, machines get upgraded, we will get a similar kind of contribution from the manufacturer again; yes. We are depending on it.

Mr. WALGREN. The gentleman's time has expired. The Chair recognizes the gentleman from Iowa, Mr. Nagle.

Mr. NAGLE. I would like to start, Mr. Chairman, by a statement. In your testimony you make reference to the fact that during the 1970's, the United States neglected its research and engineering base, and just for the record, I would like to state that I had the staff get me the figures of what we were spending on research in the 1970's against the 1980's, and I would like the record to reflect, first of all, that as of 1980 exactly, the allocation of research dollars in civilian defense was approximately the same, about $15 million.

Thereafter, the Reagan Administration took office and the research dollars for civilian defense decreased and of course, as we all know, research dollars for defense increased dramatically.

We were spending at that time approximately 25 percent of our research dollars on basic civilian defense research and about 75 percent on civilian research and the ratio has been exactly reversed.

I don't think it helps the tenure of the debate that the Congress has to make its decisions to continue to blame the Carter Administration for what has obviously been a shift in research priorities conducted by this Administration, and to the extent that your testimony implies it was done before this Administration took office, I think it is erroneous and misleading.

I think the debate should clearly be for the American public. As Chairman Roe stated quite clearly, where did the dollars come from? We can see 72 percent of our dollars, under the present Administration's proposal is to go into defense as opposed to the 10 percent in basic civilian research. I think we can look to research as a commodity and we can see there is a clear shift of priorities by this Administration still reflected.

When we realize that one research project of this Administration, the strategic defense initiative, is $3.8 billion last year, a proposed increase for $5 billion this year, when the overall increase for the rest of the budget, for civilian research, hardly reflects that.

I think it's a case that the Administration has taken us away from civilian research. It is not something that happened before they took office and the debate ought to be, how do we allocate our research dollars between defense and civilian?

Having said that for the record, I'd like to focus on something else, if I might. I come from a state that is number one in the SAT test and we traditionally trade places with Wisconsin, which was also number one two years ago and is number two this year. I do not see in your testimony addressed the question of the disparity of local resources, in terms of finding and training these scientists.

I am wondering if the Administration has given any thought to the fact that not all states are created equal. Not all students live with the same resources and that the potential scientists that could be found in Pennsylvania, New York or New Jersey, might also be found in Iowa or Wisconsin, in the K through 12 level, particularly where that crunch is really being felt.

Has the Administration given any thought to the disparity of economic resources for scientific education available for state and local funding?

Mr. BLOCH. Well, I don't know if I can answer that question. I certainly want to answer the question from the Foundation's viewpoint. We have given that a lot of thought. We have looked at where our money goes and how much goes state by state, institution by institution and so forth.

As I have mentioned a number of times before, last year in this Committee, in the hearings, that we have two goals to fulfill, as far as the Foundation is concerned. First of all, we have to make sure that our science and engineering stays at the forefront and that it is the best in the world. That is one goal we have to fulfill. The other one is essentially to make sure we broaden the participation and by broadening the participation, I mean in terms of people as well as in terms of institutions.

We have looked at that problem. We are doing fairly well with regard to the second one, not perfect. Nothing in the world is perfect, but we are doing fairly well on the second one.

We are supporting a lot of universities all over the country. We are supporting many of the activities in different types of institutions, four year colleges as well as research universities, as well as the teaching universities.

Is our record perfect? No, it's not perfect, but on the other hand, we have focused on exactly that problem.

Mr. NAGLE. Well, I think you have focused on it from a university standpoint but I'm questioning whether or not we have really addressed the question of what do we do with the K through 12 educational or scientific research or scientific education that is available. I haven't seen that really debated.

Mr. BLOCH. Well——

Mr. NAGLE. Let me, if I can, frame this a little better for you. We have 19 states right now that are basically in periods of high economic growth and obviously have resources to put into K through 12 funding for educational purposes generally, scientific and mathematics specifically. We have 25 states, all agriculture based, that have periods of no growth or recession and when we start allocating Federal dollars for scientific recruitment and scientific training, I don't see in your proposal or even in the Congress for that matter, and I'm not faulting you, a real concrete focused effort in terms of how we eliminate that disparity of opportunity.

Mr. BLOCH. Well, I don't believe that our programs, especially our pre-college programs, differentiate between those types—two types of states that you are describing, when we are doing materials development, new materials development, the results of that work can be used anywhere.

Mr. NAGLE. It can be used anywhere if they have the money.

Mr. BLOCH. Well, we are not supplying money to the localities. That's not the function of the National Science Foundation. Our function is essentially to generate and to be a catalyst to generate new teaching materials, new approaches to teaching and things of this sort. We are not supporting each and every school district in the country. The Department of Education is doing that.

Mr. NAGLE. That's my point and I don't mean—this is not a quarrel with you, although I have deep disagreement on the first part of your testimony. This is not a quarrel with you, but isn't that something we should be addressing?

Mr. BLOCH. Well, I think some of that is addressed in the Department of Education. Again, I'm not that familiar with it. I don't think you can put this on NSF—give that problem to NSF to handle.

Mr. NAGLE. Well, if NSF—if one of the primary purposes of NSF is to recruit, educate, and train scientists, engineers and mathematicians——

Mr. BLOCH. That's what we are doing.

Mr. NAGLE. Okay, but what I'm saying is, the capacity to reach out to the entire country, to my judgment, at least, shouldn't be dependent upon the local resources of where that student happens to live. I'm curious to know whether or not there is any discussion within your department, Mr. Bloch, whether or not there is any discussion within your department in focusing on the disparity of allocation of resources at the local level.

Mr. BLOCH. Well, I told you that we are reaching out and broadening the participation in terms of people as well as in terms of institutions, in all of the areas, in the research areas as well as in the education areas. I think if you are asking us to be responsible for each and every school district, that's not—we are not responsible for that.

Mr. NAGLE. Well, I'm certainly not asking you to be responsible for that, but if I could pursue this for just a second, what I'm trying to suggest to you is, is there a responsibility to see that the resources are fairly equally distributed, and factored into account in the distribution of those resources, are the local resources that are also available?

Mr. WALGREN. The gentleman's time has expired. Certainly, you may answer.

Mr. BLOCH. Let me give you one example which is a real example. We have a program which is an instrumentation program for four year colleges essentially, and what we are asking there is essentially that our dollars be matched by local dollars and that might be from industry, it might be from the state, it might be from the university itself.

If you look at our distribution in that area, it reaches out all over the country and it essentially puts instrumentation into laboratories, four year laboratories, all over the country, indiscriminately, where it is located. The deciding factor is primarily the excellence of the proposal and the matching capabilities.

That, I think, if I understand you correctly, that essentially gets at some of the problems you are citing.

Mr. WALGREN. Dr. Moore?

Dr. MOORE. Just to amplify for one second what Mr. Bloch has said, in the Directorate for Science and Engineering Education, of course, the two largest single programs for pre-college education are teacher preparation and enhancement on the one hand, and materials development on the other.

Neither of those programs is targeted at any particular geographic area, but neither of them is restrictive of any geographic area either. They are designed to stimulate and promote better teaching, both by providing improved materials and by upgrading the capabilities of teachers wherever they are applied. They are open to all comers to participate.

Mr. WALGREN. The Chair would like to move to the gentleman from Missouri, Mr. Buechner.

Mr. BUECHNER. Let me move my notes around here. I think for the record though, and I hate to be repetitive about this, but the NSF has received over a 66 percent increase during the Reagan Administration; is that correct?

Mr. BLOCH. That's correct.

Mr. BUECHNER. Actually, Congress has given less than the President has actually requested in some of those budgets?

Mr. BLOCH. That's absolutely correct.

Mr. BUECHNER. And at this time, there is a request in the budget for a 17 percent increase?

Mr. BLOCH. That's correct.

Mr. BUECHNER. So that by 1989, NSF will have doubled the budget during the Reagan Administration?

Mr. BLOCH. Right.

Mr. BUECHNER. We have been talking about the FY 1988 proposal for the Science and Technology Centers in addition to the NSF commitment to the 14 Engineering Research Centers, I think including the 3 that were announced this past week. We have the 45 Industrial Research Centers, 5 Supercomputer Centers.

What are NSF's out year mortgages with center facility commitments?

Mr. BLOCH. Well, let me address that area. First of all, if you look today at how many centers are in existence, in NSF, I'm talking about NSF, it's about 38, roughly speaking, 38 centers. You included in your bigger number some of the smaller centers which are not what I call a center, because in total dollars, they don't fall into the same class.

A center to me is one that costs somewhere between $1 and $4 million a year, you know, something of this sort. We have in existence about 38 centers.

For 1988, we would like to increase that, with the 1988 budget, we would like to increase that to about 70 centers, and then if you project these 70 centers, that once they reach a stable state, they will probably be on the order of about $3 million a center, and we would have essentially, if you don't add anything to it or subtract anything from it, we would have something like a $210 million mortgage.

Now, why did I say $3 million? Because those centers will—a lot of the new ones being Science and Technology Centers instead of Engineering Centers, and probably will come at a lower kind of a cost than the $4 million that we are paying today on the average on Engineering Research Centers. It is about a $200 million kind of mortgage to use your word.

If we go, as I hope we will, and if we double the National Science Foundation's budget, we would like to go to something like 100, 110, 120 centers over the next 5 years and that would be roughly about a $300 million kind of a mortgage.

I just want to make the point, that is about on the order of 10 percent of our total budget, so it's not an overwhelming part of our budget.

Mr. BUECHNER. What would the price tag be using that term "mortgage" for the National Center for Atmospheric Research (NCAR)?

Mr. BLOCH. That's a little bit different. That's one of our more expensive centers, because as you know, it's a stand alone center. It has an entirely different function than the centers that we are talking about, and we are paying roughly about $45 to $50 million a year for that center. That is not at a university. It's a stand alone center. It brings in university people but it has a permanent staff. It has a permanent capability of supercomputers, aircraft, instrumentation and so forth. It's a very expensive center.

Mr. BUECHNER. I think it might be good for the record if you would at a later date supply us with a list of these centers and what your predictions are for that outlay over the next few years.

Mr. BLOCH. We'd be glad to do that.

[Information to be furnished follows:]

There will be a Foundation-wide solicitation inviting proposals from the full range of scientific disciplines. NSF will identify illustrative examples while remaining open to new, unanticipated directions. Certain areas—especially multidisciplinary areas—have been identified as being ripe for rapid advances or potential application if coordinated efforts can be brought to bear on emerging, complex research topics. The specific centers to be initiated in FY 1988, however, will result from the proposal selection process.

The S&T centers concept primarily addresses centers with support in the range of $1 million to $4 million in the first year, with an average level of about $2.5 million once stability is achieved. In FY 1988 we would increase from approximately 40 centers to about 65 centers. This includes both the expansion of established activities (such as materials research laboratories, engineering research centers, industry/university cooperative research, and computer science centers), and the initiation of center activities in such areas as biotechnology, neurosciences, and minority resource centers.

If the Foundation's budget is doubled, we plan to increase to 100 or more centers over the next five years—at about a $300 million per year level, about 10% of the Foundation's research and related activities.

The controlling factor is the number of centers initiated. If we do not have the money, we will not initiate new centers.

Mr. BUECHNER. Could you also—I know your lease at 1800 G Street, N.W. is coming up. When does the lease terminate?

Mr. BLOCH. Unfortunately, it's not coming up. I think it's terminating around 1993 or 1994. I think that's right.

Mr. BUECHNER. In Washington real estate, that's coming up.

Mr. BLOCH. That's coming up, okay, then by your definition, that's correct.

Mr. BUECHNER. Are you considering moving your Washington offices and if so, where? [Laughter.]

Mr. BUECHNER. I'm not looking to invest in it. I know you are considering leasing office space in Silver Spring, NSF is, and I guess that's why I raised the question.

Mr. BLOCH. Well, that's a very controversial subject—I mean controversial inside in the National Science Foundation. I have to be very careful how I say that. Otherwise, I will have a revolution on my hands, which is okay.

The point that I want to make is the following. I think that our current space is not optimum for us. It's expensive because it's in the middle of downtown. It will get more expensive over time. It has not been maintained very well. We are leasing the space. It has not been maintained very well. Corners are being cut by the owners of the building. It's not modern enough to accommodate the things that we need to have, like for instance, work stations and the cabling for work stations.

Also, we are in a building where there is multiple occupancy. We are sharing that building with the Secret Service plus some private occupiers of the space, so we don't have much control over it.

We have been looking to go to a different location. The Silver Spring location has been offered to us. We have not made a decision on it because we have to understand exactly what it means. There is a great hesitancy to move out from downtown because it is kind of important to us because we are depending on a lot of people coming into the Foundation daily, advisory committees, panels, that we use and so forth. We have a tremendous amount of traffic from out of town. We need to be close to an airport, and hotel accommodations, and that puts some restrictions on it.

Personally, I'm convinced that eventually we will have to move out of there.

Mr. WALGREN. The gentleman's time has expired.

The Chair recognizes the gentleman from New Mexico, Mr. Lujan.

Mr. LUJAN. Thank you very much, Mr. Chairman. There's a little concern, Mr. Bloch, the number of centers that you were talking—you're going up to 20; you have what, 13 and 3 now?

Mr. BLOCH. You're talking about Engineering and Research Centers?

Mr. LUJAN. Just the three that you just announced, the Computer Centers, all of the different centers that you have.

Mr. BLOCH. Well, right now we have about 38, is the way I count them.

Mr. LUJAN. 38?

Mr. BLOCH. Sure. We have Materials Research Centers, you know, those are certainly centers. And those have been in existence for 10-years or what have you.

Mr. LUJAN. Yes.

Mr. BLOCH. NCAR was mentioned. It is certainly a center, and of Supercomputer centers we have five. We have 11 ERC's plus, I'll say two and a half after yesterday's announcement.

Mr. LUJAN. If you're committed to funding these, what happens to your other programs if you don't get the doubling of resources?

Mr. BLOCH. That was a point I made to the gentleman before, that the centers come in small packages. We are not going—If we don't get the doubling, we are not going to expand the number of centers. I think the centers that we have in place today, you know, that we can accommodate within the present budget, and we have made allowances for accommodating within the present budget.

And so, the totality of what we are spending is a small portion; it's 10 percent of the Foundation's budget. If we get a doubling, we would like to get the number I mentioned before, if you get something in between, we are going to scale it down accordingly.

In the beginning, as the Chairman asked, what do we do if we don't get or if we get cut by $400 million? Well, you know, the centers would be essentially affected by it in a significant kind of a way.

I think we have an offer for foresight and we are prudent enough in the way we are dealing with the centers that we can live with the existing centers within the framework that our budget comprises. All it means is that we can't expand the way we wanted to expand.

Mr. LUJAN. Following up on that, how successful have you been? You know, there's supposed to be industry cost-sharing and all of that, have you been——

Mr. BLOCH. I think we have been very successful. I hope we continue to do that. Let me give you two numbers. I mentioned before in the Supercomputer Centers we are paying 60 cents on the dollar; the rest comes from the manufacturers and the states.

In the Engineering Research Centers there's—so far we have approximately—it's about one to one distribution between our contribution to these centers, which is about $13 million, and that of industry.

I hope we can continue to keep it that way. Industry and states, I should say in the Engineering Research Centers; it's not just industry.

So, I think we have been very successful. Let me give you one other number which is kind of interesting. If you look at the total leveraging that the Foundation does, in all of our programs, we are leveraging about $300 million a year, from the various sources, states, universities and private sector. And I think that's pretty good.

Mr. LUJAN. Mr. Chairman, before I forget, I'd like to ask unanimous consent that I have a statement inserted in the record immediately following the Chairman's.

Mr. WALGREN. Without objection.

Mr. LUJAN. Following up—well, I guess we've all been kind of reading that the ETA Systems was supposed to become a major contender in the supercomputer industry, and as a matter of fact, had made arrangements they were going to be in the Princeton part of the state. Now, it appears, according to one article, that their financing is reduced and there's some troubles. Are you anticipating any problems with those two universities, with those two supercomputers?

Mr. BLOCH. Well, we have been following that very carefully, because we have a great interest, obviously, in it. Personally I've been in contact with either Lloyd Thorndike as the President of ETA or with the Chairman of Control Data, probably on the average of every six weeks or so. So, I think we are fairly well informed.

It's a very delicate situation, obviously. Not unexpected, I need to say, because I've never—with regard to supercomputers—seen one yet that has made its schedule. And this is not an exception.

So, I think what we're dealing with is the nature of the beast, number one, but it's a more delicate situation because of the financial situation of these two companies. And we just got—and I have every assurance, and obviously, that's not a—that's not 100 percent guarantee—that CDC (Control Data Corporation) is going to support, continue to support, ETA.

Mr. LUJAN. One concern—one final concern that I have, this university group that you have made an announcement that the—that National New Technology Telescope was going to be in Hawaii; and that, of course, leads me to check that what are the long-term plans for other astronomy facilities, and to be more specific amongst all of those facilities, Sac Peak (Sacramento Peak) like that.

Mr. BLOCH. I figured you had that in mind. We had some discussions on Sac Peak last year and the year before. And I think what you have seen happening in the meantime is that that situation has straightened out and has stabilized.

There's a change in management there.

Mr. LUJAN. Oh, no, I meant because of the—that new one, you know, in Hawaii.

Mr. **Bloch**. In Hawaii?

Mr. **Lujan**. Yes. How does that change the situation?

Mr. **Bloch**. Well, I don't think it changes—it affects it at all. I think that's on an entirely different track with entirely different people and organization involved.

We have the installation that you're familiar with, essentially, and we're doing some of the work in preparation for technology work, in preparation for new telescopes. But we have enough on our plate right now to finish off what we have started, VLBA (Very Long Baseline Array) and so forth. We're not starting a new telescope right now.

Mr. **Lujan**. One final thing before my time expires and that's on this, bringing up kids, you know, through the sciences and those things. As a matter of a fact, there is or there are programs within NSF. Yesterday I was at Fermi Lab, for example, and I was very pleased to note a program that they have on Saturdays, that Leon Lederman put together; and you do fund that through the National Science Foundation.

Mr. **Bloch**. I hope he mentioned that to you.

Mr. **Lujan**. He most certainly did; and I was very pleased with that, both from the standpoint of Fermi Lab and the National Science Foundation. But perhaps, what the gentleman from Iowa was talking about in distribution through the states, that might be something that we could look at, through that kind of a program.

Mr. **Bloch**. Yes, I think so. In fact, Leon Lederman was in, not a few weeks ago, and we discussed exactly that. You know, if he can do it with his National Laboratory, what about the other 600 National Laboratories that are in existence. That's a very good idea, and I think we should pursue that.

Mr. **Lujan**. Take somebody, I guess with that dedication, Leon Lederman, of course, is a former professor and likes that, and as a matter of fact, when he gives you a briefing, you know, you feel like you're in school and you're really enjoying it, and he does a really good job. And I'm sure thathe enjoys his Saturday morning classes and that's why its expanded.

So, I guess we have to look for people like that, that like to do that, because they will do it well if they enjoy doing it.

Mr. **Bloch**. Exactly. Let me mention another thing in that regard, again, coming back to that distribution problem. We are sponsoring a couple of television series on mathematics, "Square One", which is a new one that is being shown throughout the country; and that addresses essentially everybody no matter where he is. And before that, "3-2-1 Contact", which was a similar kind of an endeavor, and is still running.

So, we are taking advantage of public television.

Mr. **Lujan**. I think those programs are very good. And we'll be coming to you to fund one, that's the ground work having been laid by, we have a good one for you.

Mr. **Walgren**. The gentleman's time has expired.

The Chair recognizes the gentleman from California, Mr. Konnyu.

Mr. **Konnyu**. Thank you, Mr. Chairman.

During my time in the State Legislature of California, the issue of foreign students in the University of California system came up as an issue of policy, and as a matter of fact, the Assembly Republican Caucus Policy Committee, which I chaired, came out for more of an Americanization program. The university system fought it tooth and nail, basically, on the fundamental goal, that they want the best possible students, and that, because most of the best American students left at the Bachelor degree level to business, that over half the UC system as it relates to scientific areas, scientific degrees, consisted of students in the Masters and Doctors degree program who were foreigners.

Now, as you know foreign students and researchers, notably the Japanese make ample use of our universities.

What could we do as a country to change that to a more Americanized utilization?

Mr. Bloch. Well, I would say, first of all, in doing that—first of all, we should try that, and we should put every effort behind it to make that happen, and I'll come back to that in one second. But by doing that, I hope that you don't close the door to foreign students, because that point I want——

Mr. Konnyu. It has never been the question, because, you know, Mr. Bloch, I just said that over half the UC, which is the best system, there are two university systems in California the state sponsored. The UC system, over half the scientific degrees go to foreign students.

Now, the argument is that, you know, a lot of them stay here, but there are no numbers as to how many stay in America and live here, so that we can benefit from that education.

Mr. Bloch. We have numbers. We have numbers of the graduate students who are coming here, and we know if they stay or if they go back. And a great majority today, luckily, are staying here, about 60 percent of those students.

Mr. Konnyu. So, if that were reflected to the University of California that would be an additional 36 percent.

Mr. Bloch. Right, that would stay here. And by the way, you just have to look and walk through some of the factories and laboratories in California; and you couldn't function without those students. I know the semiconductor industry very well. You walk through any of the development laboratories——

Mr. Konnyu. You may not notice, but I was a Director of Internal Audit at National Semiconductor, and I'm fully aware.

Mr. Bloch. Then you know it yourself.

Mr. Konnyu. But the question is, see, the argument that UC folks gave to us is that, if we were to do a greater effort in Americanization, we could do that. It's true. But we would lose some of the best minds in the world that are available to America, that they can attract now from Europe and from Asia, and that a good portion of those will end up staying in the United States.

Mr. Bloch. Well, I would say that there is room for both; and I think we should make a concerted effort in getting more of our students into graduate schools. And by the way, some of the programs that the Foundation has in that regard, namely, the Presidential Young Investigator Program which addresses faculty, and a Fellowship Program, which addresses Ph.D. candidates. Both of them are reserved for U.S. Nationals and persons with visas.

Mr. Konnyu. Now, if——

Mr. BLOCH. So, we're taking that—that focus that you're talking about.

Mr. KONNYU. Mr. Bloch, if we could discover a set of facts that would prove that some Japanese students or some European students or some Hong Kong students came to the United States and benefited from taxpayer sponsored education and research, and then took that over there to their countries and helped the firm beat American firms out of contracts, how would that appear or is that just a down side of a general program, that on net basis, is favorable?

Mr. BLOCH. Stated that dramatically as you just stated, it appears bad, obviously. But I want to give you—I want to make a couple of points on that and give you a couple other considerations.

First of all, many of the students who studied here got their degrees here, went back, and a lot of them joined American companies over there. I know it from my own experience with IBM. Who manned our overseas laboratories in England, in Zurich, in Japan, by the way? Nationals from those countries. Many of them having been educated here, were hired by American companies right away.

Secondly, I think we have an obligation to educate some people who then can do something for themselves in those countries. And in China, for instance, as an example; and if we do that, then I think indirectly we help ourselves. Also, as a culture which they absorb here, and when they go back they have a different attitude about this country than if they had been educated somewhere else.

Mr. KONNYU. All right, Mr. Bloch, let me switch to an entirely different area. In 1976 a member of this Committee, two members of this Committee, Mr. Mineta and I, debated on a number of issues including why the National Science Foundation sponsored research such as—I don't remember the specifics, but in general I'm correct, you know, the sex life of a bee and that kind of stuff.

Now, are you still in the business of sponsoring esoteric research which upon closer examination by the general public would be questionable at best?

Mr. BLOCH. Well, we have 13,000 awards that we are making yearly. And I'm sure there are a few in there that are in the category that you are citing; and we're trying to make sure that that is—that it's not frivolous. Okay.

Many times a title, you know, such as one that you are citing can be highly misleading of what really goes on in that particular research.

Mr. KONNYU. So, is there now sensitivity to titles, by the way?

Mr. BLOCH. No. There's certainly sensitivity to subject matters, okay. And, also, sensitivity to titles. But I think one has to look deeper than the title itself. And that doesn't excuse that some mistakes are being made or have been made. And I think we are dedicated to making sure that those are minimized. They will always happen, one or two or half a dozen, I'm pretty sure, but we are very sensitive to this, number one. And number two, a title does not always represent what goes on.

And also, one particular thing taken out of context, is a bad thing to do.

Mr. WALGREN. The gentleman's time has expired.

Mr. **Bloch**. Can I just finish that. Because you really have to look at the totality over a particular discipline to see what goes on there.

Mr. **Konnyu**. Thank you, Mr. Chairman.

Mr. **Walgren**. The Chair recognizes the gentleman from Maryland, Mr. McMillen.

Mr. **McMillen**. Thank you very much.

I would like to focus on two specific areas, biotechnology and materials engineering. In my district the largest private employer is Westinghouse. And in a recent visit there, a senior engineer from materials engineering and technology told me that if he advertised for electrical engineers he would be flooded with applicants. He would be lucky to receive one or two qualified applicants from materials engineers.

I'd like to ask you, what specific actions are you taking to remedy this shortage? Am I correct that the Materials Development and Informal Science Education activity of your Science and Engineering Directorate appears to be slightly less for the Fiscal Year 1988, Fiscal Year 1987?

Dr. **Moore**. Mr. McMillen, excuse me, are you referring to—with respect to Westinghouse, I assume you're referring to materials scientists and engineers to work on new industrial materials?

Mr. **McMillen**. Right.

Dr. **Moore**. I believe the budget line that you're looking at there is for teaching materials rather than——

Mr. **McMillen**. No, I was referring to the fact of the scarcity of qualified applicants in the field.

Mr. **Bloch**. Let me comment on that part for a minute.

Mr. **McMillen**. The item that I'm pulling off the budget is part of the Materials Development and Informal Science Education activity. Do you have your science and engineering——

Mr. **Bloch**. And Dr. Moore is right, that has nothing to do with materials science or materials engineering; that's essentially materials development, teaching materials development; new ways of teaching and so forth.

Let me make a comment.

Mr. **McMillen**. But basically those two are unrelated?

Mr. **Bloch**. They're completely unrelated. Let me make a comment on your point, however. Yes, I believe that's probably true, that materials scientists and materials engineers are far fewer than is the demand; no doubt about it. And that some of that has to do with the educational structure on where, how, and under what situations materials engineering and materials science is being taught. So, that's one point.

The second point is that you really have to look within the Foundation. If you want to know how we are supporting materials, you have to look in two directorates, primarily. You have to look in the Engineering Directorate, where it's materials engineering; and you have to look in MPS, in the Mathematics and Physical Science Directorate, where it is essentially materials science.

And there's no fine—there's no dividing line between the two. There is a broad overlap between the two. One is primarily aimed at processes; the other one, understanding the basic structure of materials. We have made a major effort in this particular area. It had good increases over time. There is right now an evaluation going on by the National Research Council on the science of materials, the total materials science and engineering area. And out of that, I'm sure will come a requirement and a demand on us what we should do in the future about that very important part of science.

We have started—some of the Engineering Research Centers have to do with materials research and materials development, by the way.

So, we have it in focus. But I'm not surprised that you get comments like you got from Westinghouse.

Mr. McMILLEN. Well, given the potential size of the industry, the rejections I've seen on them, do you feel that we are doing enough work in this area——

Mr. BLOCH. No.

Mr. McMILLEN [continuing]. Adequate enough?

Mr. BLOCH. No. We are not doing enough work in this area, very clearly. Just like we are not doing enough work in many of the other areas, and that's why we have the request in front of you to double the Foundation's budget. So, we're not doing enough.

Mr. McMILLEN. Turning for a moment to Biotechnology Research Centers, in your budget request you're requesting funds for the establishment of a number of research centers, some mini centers with industry support and participation in order to promote commercialization of these discoveries.

During the past five years, many state/university/industry biotechnology centers have been established with similar missions of advancing in commercialized biotechnology. In the State of Maryland, as you well know, we have a strong interest in this area. How will your centers, your mini centers, be different than those state centers; how will you avoid the overlap?

Mr. BLOCH. Well, first of all, the centers that—and by the way, we have a biotechnology center at MIT, which we established in 1985. The center at MIT has really three major functions. First of all, it's doing research on biotechnology manufacturing. It's really a manufacturing center which is not well understood. Many of the centers that you are talking about are primarily biotechnology centers doing science, but not necessarily the manufacturing part of it. So, that's one difference.

Secondly, all of our centers, not just that one at MIT, have all the missions; namely, the education, helping in the educational process, both at the undergraduate level and at the graduate level. So, we are putting a lot of emphasis on education in these centers.

And third, industry has to participate. In many of the other centers industry does not participate; and industry has to participate in that one.

So, I think it's on a different level, number one. And secondly, biotechnology is a broad field, and we need more—we certainly need more than one center. We have more than one center for physics; we have more than one group doing chemistry and so forth. It's a growing kind of a field, and it's of extreme importance to industry. So, we should have more than one center.

Mr. McMILLEN. Will there be some competition for industry for one or two of various centers; how do you see that work?

Mr. BLOCH. Well, I'm sure there will be some competition from time to time, and that's not bad.

Mr. WALGREN. The gentleman's time has expired.

If I could turn to the gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman.

Mr. Bloch, I missed the first part of your testimony. I was in the markup of H.R. 3. And one of the things—that is the Trade Bill, and one of the things that we're doing there is considering legislative authority for establishing a joint industry wide consortium of the major semiconductor and electronics manufacturers called Sematech. And as I understand it, you were on the Defense Science Board's special task force dealing with the rationale for a vastly expanded Pan-American effort, so to speak, in seeking to rehabilitate the world competitive position of the semiconductor industry.

Could you give us some insights as to your thoughts about this rather landmark decision, a rather strong departure from the way we've done things in the past; could you give us your views as to how you think NSF interacts, how universities might wish to interact?

Mr. BLOCH. Well, I'll be glad to.

Mr. RITTER. How we should craft our language and those kinds of things?

Mr. BLOCH. I'll be glad to do that. Yes, I was on that task force. And as you know, that task force had the responsibility to look at the semiconductor industry, and how its fortunes impact the defense of the United States. That really was the framework under which we were operating. Very quickly, we discovered obviously that whatever the effect of it is on defense, it has a similar kind of an effect on the commercial end of the business, and on the industry at large.

So—and essentially, we came up with a proposal that the government enter into the picture and co-fund, together with industry, a major kind of an effort in research, manufacturing research, to be very precise, and that's called Sematech.

I think what the National Science Foundation contributes, can contribute to it is two-fold. We are already participating with the SRC, which is the Semiconductor Research Cooperative, that is, doing essentially and sponsoring research in universities on semiconductor problems.

The funding for that one comes 99.9 percent from industry. We are putting some funding into it together with the Department of Defense also because it's really in line with our own mission of enhancing university research. It's not being done somewhere else.

What we can contribute to Sematech is a little bit different because the idea is that the work be done in industry and not in universities. That part of the funding really should come from industry and Defense.

There's one aspect to it that also has been proposed, that there be a parallel or that—one part of the function of Sematech is to sponsor university research in order to enhance its capabilities, Sematech's capabilities itself. And we probably would be interested to see what they are funding and where they are funding it, and how that interacts with some of the programs that we have in that general area. There could very well be some joint funding going on.

Mr. RITTER. As I understand, this program—we're really talking about the factory floor, we're talking about the factory floor of the future. We're really talking about the D in R&D, and perhaps, even beyond that. We're talking about the creation of new and sophisticated advanced manufacturing systems that are much more inclined towards the industrial activity within the industry.

Mr. BLOCH. That's exactly what you're talking about. But in order to do that, you also have some very basic understandings, essentially, and you have to have some very basic knowledge developed that will help you to pursue that.

Let me give you one particular example. One thing that is high on the agenda of every semiconductor manufacturer, if he had the wherewithal, is X-ray lithography using rings, the ones that we have been operating at Wisconsin, for instance, to expose semiconductor wafers. Common technology, something which doesn't exist today, but certainly could make the difference 4, 5, 10 years from now.

In order to do that X-ray lithography kind of work, you've really got to understand something about light sources, because that's what you use as a tool; and you've got to understand the interaction between the use of the material itself and that light source. Some work like that is going on in the materials area that the gentleman before just talked about.

Mr. RITTER. Mr. Bloch, I thank you. I understand that there are Committee jurisdiction differences, but I must say that as we allocate a portion of this program to the universities, I think it would be highly desirable to have NSF's input to the process. And having worked with universities over all those years, I think that would be very attractive.

One last point, one last question. With the doubling of the budget, with the creation of new centers, where is the manpower going in terms of meeting the demands placed by these new programs? Are we seeing a concomitant rise in the size of the quality work force out there, for example, at the universities which is where most of the work is done or are we doubling people, are we layering them with—and not only do they have an individual NSF grant, but now they have a center responsibility, and plus now they're managing another project. There's only so many people out there. How do you—how have you dealt with this problem where the budget seems to be rising far faster than the manpower to carry it out?

Mr. BLOCH. All of what you're describing, I'm sure is going on. Sometimes it's a doubling, of responsibilities, sometimes it's attracting and bringing new people into the act, and into the field.

Mr. RITTER. Aren't faculty sizes really quite constant?

Mr. BLOCH. I wasn't talking about faculty, necessarily. I was talking about graduate students, about post-docs, and about undergraduate students, and so forth, that we are attracting into the system. Part of our responsibility is that we want to enlarge the system essentially because, as the gentleman just mentioned, we have shortages in certain disciplines, very, very clearly. And I think we have to make sure that we have enough people in engineering and in the sciences and also as technicians available to industry, to the government, and to the universities. That is part of our mission.

Mr. RITTER. Just in closing, in the short range, though, I think we have to be very cautious about so bureaucratizing our top scientists with grant and proposal application forms and responsibilities that they really don't do any science or engineering any more. And I don't know if the NSF has engaged in a study to evaluate the additional grant-seeking and proposal-writing, and with all the new rules and regulations over the past decade for accountability, whether or not we are seeing a serious dent in the science performance and engineering research performance of our top people.

Mr. BLOCH. Not only that, we are involved, we are talking about the Florida experiment in particular. We not only are involved with it, I think we have been leading the pack. Many of the things that we have done away with in the Florida experiment essentially need to be done away with across the whole federal government. We are well aware of that.

Mr. RITTER. The gentleman's time has expired, and it might be very interesting—particularly the Science Research and Technology Subcommittee might be quite interested in a brief synopsis of this problem.

I thank the gentleman for his time.

Mr. WALGREN. We certainly would appreciate a submission on that question, and it would be helpful in focusing our attention.

The Chair recognizes the gentleman from Missouri, Mr. Volkmer.

Mr. VOLKMER. Thank you, Mr. Chairman. I too wish to apologize for not being here for the full hearing, and I'd like to ask you, Mr. Bloch, how is NSF progressing on the international geosphere biosphere program?

Mr. BLOCH. Well, I hope we are progressing well. And by that one, I mean the following. We have—we are a participant of that particular—in that particular program. We have our own effort internally which is part of that program, a very important part of the program. We have an initiative in the 1988 budget to enhance that particular area, and we are completely in tune with the overall aims of that international program.

Mr. VOLKMER. All right. Now are you cooperating with the other agencies on this?

Mr. BLOCH. Absolutely.

Mr. VOLKMER. Are you taking a position basically, though, that you are the lead agency?

Mr. BLOCH. Well, in some parts of it we are the lead agency. That's a big program, as you know, and we are not the lead agency in each and every facet, but we are certainly the lead agency in some of the parts. Particularly in the ocean research areas, we are leading the pack. We are leading the pack in the atmospheric area. We are cooperating with NASA in terms of satellite observation and so forth. We are cooperating with NOAA, which is participating in that. So we are very heavily involved.

Mr. VOLKMER. All right. Now what about our international cooperation? Have we moved into it?

Mr. BLOCH. Yes, definitely. International cooperation occurs on a number of levels. First of all, we have some individual grants, bilateral grants, where we are linking up a researcher from here with a researcher overseas. In the area that you are referring to, we have one major international program, namely the Ocean Drilling Program, that we are managing in its entirety, where we are paying the big part of the costs, where other nations participate. There are approximately 15 nations or more by now that are participating in that program. So we are doing it both on a grant basis and on a program basis.

Dr. Moore would like to add to this.

Dr. MOORE. Just one—as you probably know, the ICSU, the International Congress of Scientific Unions, has taken—it is in fact one of their programs of ICSU, the IGBP that you are referring to specifically. They announced this program last September. They have established a scientific committee that is dealing with planning for that particular program. We have been involved with the ICSU throughout this process in one way or another, and we are continuing to cooperate with them in the coordination of the various programs that are going on.

Mr. VOLKMER. Now is this not just a little bit different than what NSF is used to doing, as far as say operating a disciplinary type of program, or not?

Mr. BLOCH. I don't think it's any different from what we have been doing in the past. For instance, the Ocean Drilling Program existed in the 1970's, in fact in the 1960's. And we operated that one essentially on an international basis. So I don't think it's any different.

John, do you want——

Dr. MOORE. There are a number of other examples that could be cited. Antarctica is a prime example of an international program that we have had lead responsibility for, for many years. We are responsible for the observatory at Cerro Tololo in Chile, which is another preeminently international kind of a project. The Deep Sea Drilling Program that was mentioned is another example. And I think throughout, especially the earth sciences, including oceanography, the Foundation has long been involved and has a great deal of experience in international cooperation.

Mr. VOLKMER. Okay. Now what about—how does the National Academy of Sciences fit into your program on IGBP?

Mr. BLOCH. Well, the National Academy of Sciences has some overall responsibilities to coordinate the U.S. effort in that regard. We are working with them essentially. We are paying for a lot of their effort, I should say.

Mr. VOLKMER. Okay.

Mr. BLOCH. Right away. So there is a financial support to the National Academy of Sciences, and then there is some support in that we are working with their committees, and their committees are working with ours, as well as with those of other government agencies and government departments.

Mr. VOLKMER. It's a cooperative effort there between the two, then?

Mr. BLOCH. Absolutely, and a very close relationship.

Mr. VOLKMER. Okay. Thank you.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Volkmer.

The Chair recognizes the gentleman from Pennsylvania, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Over the last few days there have been a number of articles in the newspapers on superconductivity, and some of the new discoveries in the field, and I understand you discussed some of the materials on that earlier, and I won't go over that ground, but one of the articles—I think it was the one from The Wall Street Journal—contained this—contained some information that the Japanese are seeking to commercialize these new conductors at a rapid pace.

And one of the statements made was by a government scientist in Japan, that there are some problems to overcome, it will be difficult, and it will take time, but that's precisely where Japan labs and makers have the edge.

What are we doing to assure that having created some new technology here, that first of all we are going to protect our intellectual property; and secondly, that they don't have the edge in terms of getting this highly important industrial phase of it underway?

Mr. BLOCH. Well, before you came in, sir, we discussed the origin of that discovery, and we have got to say that they are international, the origins are international. Some of the work has been done here, some of the work has been done in Europe, some of the work has been done in China. So we can't claim that it was all done within the United States. But that's beside the point.

Mr. WALKER. Well, yes, that's right, but——

Mr. BLOCH. I just wanted to point that out.

Mr. WALKER. If the application becomes a Japanese application, it doesn't matter, we would still be behind.

Mr. BLOCH. On that point, let me say the following.

First of all, I think that it has created a lot of excitement in all of the national laboratories, certainly; in all of the universities that have—you know, that work in the materials area. So I think there has been a groundswell of work going on.

In many of the industrial laboratories, a lot of work is going on in GE, in IBM, in AT&T. I think they were mentioned, maybe not in that article, but in another article. And in the end now, we have to depend on the private sector to commercialize that particular product. And they have to be as quick on their feet as their Japanese competitors are. It's the old story, and I hope we can bring it off. But I'm not so sure that it is a national tops-down directed kind of an effort that's required. I think what is required is that we exchange the information very rapidly between university and the industry, and that industry then address the problem as forcefully as they can, and as forcefully as their competitors are doing.

Mr. WALKER. Do you agree with these Japanese government scientists that Japan's labs and makers have an edge on us in this area?

Mr. BLOCH. They have shown that they can move very fast, and——

Mr. WALKER. Okay. By doubling the NSF budget, are we going to do anything to correct that problem?

Mr. BLOCH. To correct that problem? Not directly, no. And I don't think that's what we are promising. What I hope can happen by doubling our budget is that more things like the superconductor discoveries will come forward. It has a bearing on our whole economic competitiveness and also on preparing the people for it.

Mr. **Walker**. We have essentially funded now the discovery of the supernova at the observatory in Chile. I mean it—that's right, isn't it, through NSF funding, that we have in fact funded that?

Now as I understand it, having been with Mr. Lujan out at Fermi yesterday, you know, basically what we have when we talk about the Super Collider is people who are looking at the origins of the universe from different spectras: One, the astronomers, one at the other end with the Super Collider. Since the investment of the Super Collider is such an enormous investment, is it possible that the data that we are going to get in the discovery of the supernova, if put into computers and analyzed and so on, would give us some information that we could utilize that would keep us from having to make the investment in the Super Collider?

Mr. **Bloch**. I don't believe so, no. I think those two scientists, while they are looking at the same kind of phenomenon, are operating at two entirely different levels, and I think people will still want to know what goes on deep in the atom. Even so, you might know a lot of what goes on in the universe.

Mr. **Walker**. What are we doing to make certain that the supernova discoveries and so on are in fact disseminated through a variety of disciplines?

Mr. **Bloch**. What are we doing so that they are disseminated?

Mr. **Walker**. Yes. Making sure that the information that we have derived from the supernova is being disseminated to a variety of disciplines beyond the astronomy community.

Mr. **Bloch**. Essentially what we always do, papers are being written, papers are being published and they are available to the whole community. That's how the whole science enterprise really operates.

Mr. **Walker**. Yeah, I understand that, but I also understand that we seem to be falling behind some of our international competition in our ability to respond. I guess what I'm asking is what are we doing to assure that the kind of competitive edge that we keep hearing so much about in the Congress is in fact something which is driving NSF at this point?

Mr. **Bloch**. Well, our whole budget proposal is really aiming at that particular area. Education is certainly an important aspect of that. The establishment of centers is an important aspect of it. The focus that we have on—and we discussed that before you came in here, that we have on manufacturing research is an important aspect. So you find it throughout our budget proposal.

Mr. **Walker**. The Navy recently announced that they are going to pull our bases out of New Zealand. What impact is that going to have on our Antarctica program, and is that going to end up causing us budgetary problems through NSF for the Antarctica program?

Mr. **Bloch**. Dr. Moore.

Dr. **Moore**. I'm not completely sure that that is an official decision as yet. I have seen the report that that is likely to be the decision. Those bases—the—our supply base, our main supply base for our activities in Antarctica is, as you know, at Christchurch in New Zealand, and if we were to lose that base, if we were to lose access to that base, it would have a severe negative impact on our ability to supply our programs in Antarctica.

Mr. **Walker**. One article I saw indicated that you could move it to an Australian facility probably. It seems to me, though, from what little I know of my geography down there, having been there, it's quite a bit distant, more distant from Antarctica, is it not?

Dr. **Moore**. It is enough further distant to create serious problems in the supply line, both from the standpoint of the payloads that the aircraft can carry, and from the standpoint of safety, in case of weather problems upon arrival in Antarctica.

I'm not an expert in this area, but the experts tell me that that puts it right at the edge of marginality.

Mr. **Walker**. We would be in danger, perhaps, of losing the McMurdo Station at that point?

Dr. **Moore**. Well, I'm not sure we'd say that, but we would say that it would have a severe negative impact on our ability to operate that station.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. Chairman, Mr. Buechner was seeking to ask a question here, and I——

Mr. **Walgren**. The Chair would be happy to recognize the gentleman from Missouri.

Mr. **Buechner**. I've been listening to the discussion that we had. The gentleman from California was talking about the number of foreign students that come in and, of course, in our various research facilities the Japanese over the years have been very adept at sending people in to participate and to glean information—I'm not talking about anything that's nefarious, any theft or anything like that, but being able to learn and to take that absorption of technology and knowledge, and take it back to their country and utilize it.

Are there any similar programs available in Japan that we can send our top students or people willing to go there and to get a reciprocal absorption, if that might be the proper term?

Mr. **Bloch**. Yes, there are, and we have been addressing that. Let me give the prime example of that. There is a Japanese program which is called the Fifth Generation Computer Program, which is really looking far out in terms of research, how to construct better machines, parallel machines and so forth. It's a program that was established jointly between the Government, Government laboratories—when I say Government, we mean industry and universities. That program has been in existence for four years now, and continues to do very good and very important kind of research.

We just negotiated about nine to 12 months ago an agreement with—it's called ICOT, with ICOT, or the Fifth Generation Computer Program, that allows us to send at any point in time up to three United States researchers over there (to Japan) for extended period of times, extended periods of time of nine to 12 months to 15 months, not just two or three days, and we are going to insist on that kind of quid pro quo across the board.

As you know, university research in Japan is not what it is here. It's——

Mr. **Buechner**. That's why they're here.

Mr. **Bloch**. Well, that's partly why they are here, that's right. But a lot of good research is going on in programs like ICOT in the Government laboratories and in industry. We can't do much about industry, because we can't open up our labs, either. But the Government labs, the Government end of things, we want to open up as much as we possibly can. We made a first step.

Mr. **Walgren**. Thank you, Mr. Walker, Mr. Buechner.

I had a couple of other thoughts I wanted to raise.

Would the gentleman like to pursue——

Mr. **Buechner**. I just have one more question, if you don't mind, Mr. Chairman, and that deals with technology. The—Monsanto has its world headquarters in my legislative district, and I'm—and they're on the forefront of biotechnology, and I would like to know that in the grants for biotechnology in the Biological Behavioral and Social Sciences Directorate, what type of—do you feel that biotechnology is going to be one of the leading areas that you are going to be pushing? Are you going to be establishing any biotechnology centers? Have you got any idea of some of the advancements that you are looking forward to? And as a final, is our budget sufficient for this area, which I think the United States has the leading edge and really has the ability to continue that advancement.

Mr. **Bloch**. The answer is yes, that's one of the foremost areas that we have been singling out as deserving a lot of focus and a lot of effort.

As I mentioned before, there is one Biotechnology Center that has been—that is in existence, which has been in existence for about three years now up at MIT. There are also centers being planned in that directorate essentially, and as our budget gets approved, you will see a heavy focus in that whole center area on biotechnology. Definitely.

I should also mention, since you brought up Monsanto, that a new member of the National Science Board is from Monsanto, namely Dr. Schneiderman, who is Senior Vice President of Research and Development at Monsanto, and he makes a very good case for biotechnology.

Mr. **Walgren**. Thank you, Mr. Buechner.

The question of balancing big science and all the other needs of science, and as we rush down the road towards a Superconducting, Super Collider, do we have a strong, strategic priority plan as a nation to decide what big science programs to pursue? Or are we doing this on a rather ad hoc basis?

Mr. **Bloch**. Well, if—I think we are doing much of it on an ad hoc basis, no doubt about it. Because, as you know, there is no overall budget essentially that is being reviewed in Congress with regard to science and technology. It's split up into many individual pieces.

Obviously the science advisor and OSTP have overall responsibility to make sure that the balance in totality is correct. So we are depending on that to happen.

I commented before already on the priority between doubling the Foundation's budget and SSC, how I see it, and also how the President expressed it in his submission.

Within the Foundation, we have a powerful mission, namely the balance between big science and small science, which are not good names, by the way, but we will use it and you have used it, so I will use it also. But between centers and groups on the one hand, and disciplinary programs on the other, and we have that constantly under review. We will make sure, that the two don't get out of bounds. You should realize that the overwhelming portion of the Foundation's budget—and I know you realize that—is really in the individual grants, in the disciplinary programs, and the facilities that support disciplinary programs. Over $1 billion, or over 60 percent, over 60 percent is in that particular area.

Mr. WALGREN. I'm sorry, which area was that?

Mr. BLOCH. The area of disciplinary grants and facilities that support disciplinary grants. It's about 64, 65 percent of our total budget.

Mr. WALGREN. Thinking back on the role of OSTP, are you, as the head of the National Science Foundation, involved in any structural way in contributing to this setting of priorities and blessing of projects that we have seen with the SSC?

Mr. BLOCH. Well, again, a bit—here and there is the only way I can say it. There are a series of committees that have been established that we participate in. Dr. Moore is on the international committee. Who is on the computer committee? I think Dr. Bell is on the computer committee that is overseeing networking and computer research in general. I have urged the science advisor to coordinate the center activities across all of the federal government, which the President mandated. So I think we are going to get into discussions on that.

Mr. WALGREN. Yes. Well, certainly there is—if you are only involved here and there and in bits and pieces, I think we have to say that there is not a comprehensive involvement of those who we would hope would be intimately involved in those kinds of priority project initiatives that have so much of an implication for the rest of science as the size of that particular budget does.

Let me ask how the NSF tries to pull resources from other agencies and how resources from NSF are pulled from you? And I'm thinking, for example, of the new center that apparently has been approved in conjunction with the National Institutes of Health involving emerging cardiovascular technologies. Now apparently we are going to provide, the National Science Foundation, about one third of the funds; is that right?

It's my understanding that we are providing one-third.

Mr. BLOCH. No; two-thirds.

Mr. WALGREN. It has been my impression that NIH budgets have been much fuller than NSF budgets. Here we have an area that is right on their mission, and certainly it's one which we are interested in, but I question whether the two-thirds from NSF and the one-third from NIH, when they are the rich boy on the block, would be the proper balance.

Mr. BLOCH. Well, let me say one thing. A minimum of one-third has to come from NIH. It doesn't set an upper limit. It sets a floor in place. Let me comment on that proposal.

I thought long and hard about that proposal before we let it go to the National Science Board for consideration, because I was kind of perplexed by it in the following sense. While a big portion of that proposal really has to do with what we are doing in the National Science Foundation, namely engineering research, a lot of the questions in the proposal and a lot of the points being made in the proposal have to do with medicine, no doubt about it.

The total application and also the interest in the end result obviously is NIH-oriented. So it was smack in the middle between—on a boundary line between NSF and NIH. The best that I could figure out for myself, and which the Board confirmed, is that we both should jointly fund that particular program. It wasn't the question of one or the other, because we both had some very material interests in it. The one-third/two-thirds thing, you can argue with that, obviously. I think it was right that we jointly fund it.

Dr. MOORE. If I could just make a comment, not on that particular center but a little more generally. I think it is reasonable to say there is a lot of cooperation between the NSF and other agencies in the way of joint funding of particular projects and even centers for that matter.

There is a recent example this year in a Plant Research Center that is essentially a Biotech Center that is jointly funded by ourselves (NSF), Agriculture, and Energy, with one-third funding from each of the agencies that are participating, and then there is a good deal of cooperation and joint funding of major international projects, going back to the discussion we had earlier of the global geosciences, where we participate with NOAA, with NASA, with the Navy, and with other agencies in the joint funding and sponsorship of various projects.

Mr. BLOCH. May I make one more comment on that?

Mr. WALGREN. Certainly.

Mr. BLOCH. It's not a question of pulling money away or bringing money into the Foundation. In the plant biology area that Dr. Moore mentioned and the case you brought up and many of the other cases, it's a question that the mission is really split between many agencies and we should work together in funding. It's not a question of do we transfer money from here to there or anything like that. It's joint cooperation.

Mr. WALGREN. I guess what I'm wondering is why an area that is heavily involved in that mission, that they might not be more forthcoming and admittedly, with your range of budget, you are put in the position of often saying that you can only be a catalyst. Catalysts are generally not seen as two-thirds of the momentum exerted, and that is particularly true when these other agencies have been the ones that have more legitimately had the funds available to them.

No, I take that back, have traditionally had the funds available to them because of the political momentum of their missions and the fact that our public policy has not really fully developed the role of basic research in terms of its Federal funding compared to what it has done in other areas of research.

Mr. BLOCH. It's really this catalytic role of NSF that brought this proposal into being. If we hadn't gone out with the Engineering Research Centers initiative, this proposal might never have materialized. It was jointly put together by the Medical School at Duke and by the Engineering School with participation from other institutions.

Mr. WALGREN. Let me ask you another question that would be along the same line. Are you ever in the position of having mission agencies pull back on research plans and then you are asked to fill in behind?

Mr. BLOCH. I don't know of any case like that.

Mr. WALGREN. But it could be a developing problem as they are going to face, and perhaps more properly so, budget reductions compared to NSF.

Mr. BLOCH. Well, that could be the case except that we really need to guard against that because in totality, we are not spending enough money as a country in basic research, so we really have to guard against that happening.

Mr. WALGREN. We also have to guard against the monies that are attributed to NSF from being driven by some of these other agency decisions and I think of funding for "3-2-1 Contact" in the educational area, where the Department of Education wants to pull back.

Is there any way that we can hold them in to a greater degree?

Mr. BLOCH. John?

Dr. MOORE. We have been engaged, as you know, in long discussions with the Department of Education on exactly that particular project. We are still negotiating with them over that. If you have a good ready answer as to how we can conclude that, I'd appreciate having it.

Mr. WALGREN. Well, I don't. It's just a problem that strikes.

On the question of the strategic plan for education, we have a science and engineering education strategic plan for the years 1987 through 1991. It has been pretty roundly criticized by some in the educational community as not really structuring a plan that can be evaluated, that there aren't enough, as I understand it, targets and timeframes and estimates of resources that are going to be required so that those in a position to make a judgment about how well this will accomplish the goals can offer constructive criticism.

I guess I have to ask you, have you thought of asking for more detail in that plan as we go forward?

Mr. BLOCH. No, I haven't thought of asking for more detail. I would certainly say that we would be glad to sit down with whomever made these comments and this critique. We are sensitive to that critique, and we can discuss what we can do to improve that plan. We would be glad to do that.

Mr. WALGREN. Well, we might be able to be a conduit of some conversations in that area.

I understand in international cooperation, we have established some NSF international offices abroad. Is that the case and how much effort is going into that? What is the cost? What is the mission?

Mr. BLOCH. We have one office in Japan and one office in Paris that we are reviewing right now. Let me talk about the one in Japan first. I think it is a very important office because it's not easy to walk into Japan and get access to laboratories or get access to Government agencies and Government offices and by having a presence in Japan, we have been able to foster that entry into Japanese Government and Japanese universities.

I feel very strongly that we need that. It's difficult to do. We have one American over there and we have two or two and a half Japanese employees. Two and a half because we are splitting time with somebody. The total cost of that office is around $300,000 a year. I think that is what it costs us. It's expensive. I think it's worthwhile because of the difficulty of gaining access and I have used that office extensively.

They are also responsible for sending information back so they are a collection source for information that we can distribute to academia and industry over here, and we have done that.

The office in Europe has only been in existence for a year, roughly speaking. It's one individual with a secretary. Again, the individual is an American. The idea again was to open up communications not only with—it's located in Paris—not with France, but with Europe in general and especially with some of the European programs like ESPRIT. We have to see how that office develops. It's not an inexpensive proposition. I think we are spending what, on that, John? About $200,000 a year.

Those are the only two foreign offices that we have. I feel very strongly about the one in Japan.

Mr. WALGREN. Well, I think you would find a lot of support for that effort, particularly given how little other agencies of the Government are doing, and I'm thinking of the Department of Commerce. I think we were able to find $60,000 related to access to technical information from Japan and $60,000 doesn't go very far.

Mr. BLOCH. You can't even make a phone call in Japan. [Laughter.]

Mr. WALGREN. A year ago or so we had theoretical mathematicians making a point that the support for their subject matter in the United States is fast declining and that in terms of theoretical mathematicians, they would be an endangered species before long in our educational system.

Can you assure us that you are sensitive to that and there is some programmatic response that would strengthen the pure math in view of how fundamental that is to everything else that we do?

Mr. BLOCH. We have had that particular problem in view for the last three years. We have done extraordinary things with mathematics, and most of it, by the way, goes into pure mathematics, not into applied mathematics. It is certainly true that that discipline has been neglected over the years; no doubt about it. We have been trying to build it up inside the Foundation with significant increases. We have also urged that community to go after other Federal departments such as DOD. They have done that. I think mathematics today is in better shape than it was three years ago.

Have we solved the total problem? No; we have not. It has had extra emphasis, extra priority over the last three years. You just have to look at the increases of that department or that division versus that of other divisions and you can see it.

Mr. WALGREN. Well, certainly we will be looking for that because that's a matter of fundamental concern.

Mr. BLOCH. And we agree with that.

Mr. **Walgren**. In fiscal 1988, we proposed 10 to 15 new Science and Technology Centers. As I understand it, there is not a budget amount that is broken out of the budget for those 10 to 15. How do we measure the amount of resources that are intended to be directed in that area?

Mr. **Bloch**. We would be glad to submit that to you and break it out of our budget request. We will make that clear to you.

[Information to be furnished follows:]

In FY 1988 we anticipate that it will require approximately $17 million to support the 10 to 15 proposed new Science and Technology Centers.

Mr. **Walgren**. We would like to have the opportunity to submit other questions to you. We appreciate your discussion with the Committee this morning.

The Committee will be marking up this area soon. You have certainly been an available source of information for us. That's very important to our process.

I couldn't close without re-emphasizing the importance of pre-college education and the educational function in general. There are some holes in that area that we want to fill with you and we will be trying to provide support for our part and trust that you will as well.

We genuinely want to salute the focus on productivity and the contributions that can be made through science and technology in international competitiveness. We think that's a critical thing, not just because it is on the agenda but because of the period we are going into.

The National Science Foundation has literally the keystone role to play in this, as I know you recognize. We hope that we can broaden the recognition of that here in the Congress in hopes that we will be able to successfully make progress over the next several years.

Mr. **Bloch**. Thank you.

Mr. **Walgren**. I do want to express the appreciation of all the members of the Committee for your being available to us. We find it very helpful.

Mr. **Bloch**. Very good. Can I say one word? We would be glad to work with you in pre-college and any other subject matter between now and mark-up and any other data that we can provide for you, we would be glad to do so. I appreciate having had the extensive opportunities of interacting with this Committee and your Subcommittee over the last few weeks.

Mr. **Walgren**. We have said several times this morning about how you have the balance between the center effort and the individual research programs, all under consideration. That clearly is very important.

I guess I would like to ask at some point that it rise to some kind of structural evaluation within the National Science Foundation, so that we institutionalize the continuing consideration of that problem, the importance of the Science Foundation as the only source for individual investigators to go to in many areas of basic research in our system I think means we have a real priority that has to be fulfilled in that area.

I think it also can be recommended on the basis of serving the geographic distributive function of the Science Foundation that is recognized in the charter and does concern a lot of members of Congress who are very interested in equal participation of various regions of the country in the scientific effort.

Mr. BLOCH. We are well aware of that. By the way, you are forgetting NIH when you say we are the only agency for individual investigators. There is a big one.

Mr. WALGREN. No, that is certainly true. My only fear is that our budgets in this area are so constrained that we become not available to the individual investigator as a practical matter, even though in theory we have a window that they can approach. It's not unlike other areas of Government where the programs tend to be diminutive compared to the proper demand and then the people who are trying to work in that area get discouraged because as a practical matter, their proposal cannot rise through the sea of others.

Mr. BLOCH. One thing I need to point out. If you look at the mechanisms that we have internally, like advisory committees, panels, individual reviewers for the proposals, many of these obviously are filled by individual investigators and not by directors of centers or anything like that. That is where a lot of the policy of the National Science Foundation gets formulated in terms of the support to the individual disciplines.

We have a tremendous amount of input from exactly that group of people whom you are rightly worried about and that we are worried about.

Mr. WALGREN. I think it would be helpful if somebody would send us the effort and degree to which the non-bureaucracy is involved in reviewing and in evaluating the grants. I know it is extensive. I think certainly to be feared would be the in-house bureaucratic evaluation and selection of all efforts made, because we know bureaucracies do not function very well and immediately run to non-risk and comfortable channels.

Mr. BLOCH. Mr. Chairman, rest assured, I'm scared of bureaucracies in general. I always tried to minimize bureaucracy wherever I have worked before and wherever I have been.

Let me just make another point. I don't think that kind of a bureaucracy can happen in NSF, not only because of the advisory committees and so forth, but within the NSF structure, we have a large number of temporaries and rotators who come from universities and go back to universities in one or two years, spending one or two years with us, and that gives us essentially another input that is very important. These are people who are doing program management for us, doing program evaluations for us. They are at that very critical level where we make decisions on grants and everything else.

I think it would be very difficult for the arteries to harden within the National Science Foundation.

Mr. WALGREN. Well, perhaps in addition to the thought of the role of the advisory commissions and the individual evaluations, we ought also to add on a question of the advisory groups that contributed to the science and engineering education and strategic plan. We would be interested in who was involved in giving advice to the development of that plan in a formal way and who might not have been involved. We would like to see the broadest inclusion that we can.

On behalf of the Committee, thank you very much for your continuing cooperation and presence as a resource to us and we want to be the same for you and those others in the Administration that are trying to do the right thing in science and technology.

Thank you.

[Whereupon, at 12:35 p.m., the Committee recessed, to reconvene at the call of the Chair.]

APPENDIX 1

Statement of the Hon. Terry L. Bruce, a U.S. Representative From the State of Illinois

STATEMENT BEFORE THE SRT SUBCOMMITTEE NSF HEARING 2/19/87

THIS MORNING I WISH TO THANK THE CHAIRMAN, THIS COMMITTEE AND TODAY'S DISTINGUISHED PANEL OF WITNESSES FOR PARTICIPATING IN THIS INITIAL HEARING ON THE 1988 AUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION.

AS WE ALL KNOW, THE NSF IS IMPORTANT TO OUR NATION. INDEED, IT PLAYS A CRITICAL ROLE IN OUR NATION'S EFFORTS TO REMAIN COMPETITIVE AND TO IMPROVE PRODUCTIVITY BY SUPPORTING RESEARCH AND EDUCATION ACTIVITIES IN ALL FIELDS OF SCIENCE AND ENGINEERING. TODAY THE NSF PROVIDES SUPPORT TO MORE THAN 2000 COLLEGES AND UNIVERSITIES AND OTHER RESEARCH INSTITUTIONS ACROSS THE COUNTRY. NSF-FUNDED RESEARCH AND EDUCATION ACTIVITIES PROVIDE IMPORTANT NEW KNOWLEDGE WHICH OFTEN LEADS TO ADVANCES IN IMPORTANT AREAS INCLUDING NATIONAL DEFENSE, ECONOMIC GROWTH, HEALTH, ENERGY, ENVIRONMENT, AND AGRICULTURE.

THE NSF IS ALSO IMPORTANT TO THE STATE OF ILLINOIS AND TO THE UNIVERSITY OF ILLINOIS PARTICULARLY. THE RELATIONSHIP BETWEEN THE NSF AND THE UNIVERSITY OF ILLINOIS CHAMPAIGN-URBANA HAS BEEN A LONG AND PRODUCTIVE ONE. IN ADDITION TO MANY EXISTING NSF ACTIVITIES AND PROGRAMS AT THE UNIVERSITY OF ILLINOIS, THE NSF RECENTLY ESTABLISHED AN ENGINEERING RESEARCH CENTER THERE.

THE ERC'S PROVIDE AN ESSENTIAL BASE FOR ENGINEERING RESEARCH AND CAN FURNISH INDUSTRY WITH A SOLID KNOWLEDGE FOUNDATION FOR ITS DEVELOPMENT, APPLIED RESEARCH, AND MANUFACTURING EFFORTS. THE PROGRAM ALSO FEATURES AN EDUCATIONAL COMPONENT AIMED AT GIVING BOTH GRADUATE AND UNDERGRADUATE STUDENTS EXPERIENCE IN WORKING WITH INDUSTRY-RELATED RESEARCH.

THE UNIVERSITY OF ILLINOIS IS ALSO EXTREMELY PROUD OF THE FACT THAT THE NSF CHOSE TO LOCATE ONE OF ITS SIX NATIONAL SUPERCOMPUTER CENTERS IN CHAMPAIGN-URBANA. THE SUPERCOMPUTER CENTER PROVIDES THE SCIENTIFIC AND ENGINEERING RESEARCH COMMUNITY NOT ONLY WITH ACCESS TO ITS ADVANCE COMPUTING AND NETWORKING CAPABILITIES, BUT IT CAN ALSO DEVELOP THE REQUIRED SOFTWARE AND SYSTEMS FOR EFFECTIVE USE AND PROVIDE VALUABLE TRAINING OPPORTUNITIES FOR STUDENTS AND RESEARCHERS.

SUCCESS IN THE EFFORT TO IMPROVE OUR NATION'S PRODUCTIVITY AND OVERALL COMPETITIVENESS WILL, IN PART, BE DEPENDENT ON A SOUND AND VIBRANT SCIENCE AND TECHNOLOGY BASE. CONGRESS MUST CONTINUE TO ASSIST THE NSF WITH ITS MISSION TO SUPPORT EXCELLENT SCIENCE AND ENGINEERING RESEARCH AND EDUCATION.

TODAY I WOULD LIKE TO WELCOME REPRESENTATIVE MARTIN SABO (D-MN) AS WELL AS DR. NEAL, MR. LEE AND DR. STRAUMANIS. I LOOK FORWARD TO THEIR REMARKS TODAY AND I LOOK FORWARD TO OUR NEXT HEARING WHERE ENGINEERING RESEARCH CENTERS AND THE NATIONAL SUPERCOMPUTER PROGRAM WILL BE DISCUSSED IN DETAIL. THANK YOU.

APPENDIX 2

CRITIQUE OF THE NSF FIVE YEAR PLAN BY THE NATIONAL SCIENCE TEACHERS ASSOCIATION

NATIONAL SCIENCE TEACHERS ASSOCIATION
1742 Connecticut Avenue, NW, Washington, DC 20009 (202) 328 5800

March 2, 1987

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Lakeland Community College, Mentor, OH

An Affiliate of the American Association for the Advancement of Science

Honorable Doug Walgren
Chairman, Subcommittee on Science,
  Research, and Technology
Committee on Science, Space and Technology
House of Representatives
2319 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Walgren:

Thank you again for inviting the National Science Teachers Association to testify before your subcommittee. I hope that the testimony we gave will be helpful to you and your committee as NSF's 1988 authorizations are prepared.

You asked me to prepare an analysis of the NSF update of its five-year strategic plan for Science and Engineering Education. I have distributed that plan to experts in the field, received back suggestions and advice, and have prepared for you an analysis and recommended changes.

An almost unanimous response has been that this update, and the plan itself, meet almost none of the requisites of a strategic plan. It gives overall goals with little or no detail on how to achieve them. It lists programs and gives examples of programs, but lacks the kind of specificity which is essential to a strategic plan. You and Mr. Boehlert's letter of March 11, 1985, to Erich Bloch, made very clear what was needed: "These specifics concern resource allocation and expenditures, staffing patterns, objectives, expected outcomes, and projected milestones."

Why has the NSF chosen to ignore your very clear specifications for a strategic plan? My analysis will show deficiencies in the plan and offer the kinds of appropriately specified subplans needed to address the well documented problems making up the science and engineering education crisis facing the nation.

Thank you again, and if the NSTA can be of further assistance, please let me know.

Sincerely,

Bill G. Aldridge

Bill G. Aldridge
Executive Director

cc: Rep Edward Boland
    Senator Edward Kennedy

35th NSTA National Convention, Washington, DC, March 26-29, 1987

APPENDIX 3

CRITIQUE OF THE NSF FIVE YEAR PLAN BY THE GREAT LAKES COLLEGES ASSOCIATION AND THE ASSOCIATED COLLEGES OF THE MIDWEST

THE INDEPENDENT COLLEGES OFFICE
[illegible] OFFICE OF THE GREAT LAKES COLLEGES ASSOCIATION AND THE ASSOCIATED COLLEGES OF THE MIDWEST
Suite 512 • [illegible] M Street, N.W. • Washington, D.C. [illegible] • [illegible]

April 1, 1987

INFORMATION
COPY

The Honorable Doug Walgren
Chairman
Subcommittee on Science, Research and
Technology
House Committee on Science, Space and Technology
2319 Rayburn House Office Building
Washington, D.C. 20515

Dear Representative Walgren:

I am responding to your request during hearings on the National Science Foundation budget that I provide comments on the agency's strategic plan for science and engineering education.

The National Science Foundation's strategic plan for science and engineering education, fiscal years 1987 through 1991, sets out undergraduate science, engineering and mathematics education programs in effect and planned for 1987 and 1988. It provides nothing but generalities for years after that. We believe a listing of clearly defined programs set for each year of the five and projected funding levels for each year would provide an improved format, on the order of this improvisation for some of the programs described on page fourteen:

Year and Projected Funding

Program	1987	1988	1989	1990	1991
Major curriculum development					
Calculus	0	2.0m	-	-	-
Engineering	0	5.0m	-	-	-
Other:					
a.	0	-	-	-	-
b.	0	-	-	-	-
Minority Resource Centers	0	-	-	-	-

The five-year strategic plan does not strike at the issues, it glosses over them in vague language. For instance, the expression "leadership activities" is never defined. The document is more like a public relations piece. Whatever NSF does in the next five years it may be said to have fulfilled these vague promises. Some of our concern is based on the presentation of several programs as current when they are not. (Undergraduate curriculum revision, research experiences for high school students and assessment of what is taking place in the field of science education are proposed for fiscal 1988. Undergraduate student research was initiated in fiscal 1987. See page three.) The Foundation "continues ... at all levels" its diverse activities according to the first sentence on page four. For undergraduate education, this diversity refers to but one science education program.

On page fourteen, NSF refers to "Comprehensive proposals." Is NSF talking about the College Science Improvement Program or the Comprehensive Assistance to Undergraduate Science Education (COSIP-CAUSE) programs? We have these clearly defined and workable models of "comprehensive" programs but this document is not clearly endorsing the reintroduction of that format. NSF should provide Congress with enough information to understand what is meant by a term before it asks approval and support.

I would hope that the joint efforts of NSF and the Education Department (ED) referred to on page thirteen will be examined closely before they are approved. We believe the plan should be very specific here on what role ED is to play. We do not want to see that department given a foothold in this area. The design and data base activity for measuring the qualitative and quantitative values of undergraduate science, mathematics and engineering is a clear responsibility of NSF under its Congressional mandate. We do not believe NSF should shift any of this responsibility to ED.

The description of undergraduate research participation on page fifteen differs significantly from the NSF's newly-instigated Research Experiences for Undergraduates (REU) program. This support "for faculty ... to work with their students on research" (emphasis mine) is superior to REU which requires that faculty work with outside students as well as their own on a fifty-fifty basis. NSF has a good model of an effective, workable program in its former Undergraduate Research Participation program.

I am concerned about the vague language on undergraduate curriculum initiatives. We need a commitment from NSF to enhance the science and mathematics curriculum for its various constituencies: faculty, apprentice scientists and potential scientists. Special attention to introductory undergraduate courses, where would-be science, engineering and mathematics majors are all too often screened out or frightened off, could go a long way to encouraging students toward science careers. Beginning courses are frequently intended to be gatekeepers. (How often are the gates closed to women and minorities who may come to college with less preparation in science and mathematics?) Raking the coals for the best prepared is an elitist notion not a democratic one.

This plan lacks balance. NSF should be committed to establishing and maintaining a proper balance of support to all levels of science education: precollege, undergraduate and graduate. We see no commitment here to programs, to timing or to funding, which will keep the undergraduate effort in balance with precollege and graduate science education offerings.

The degrees of specificity in the plan -- more detail for graduate, some detail for precollege and very little detail for undergraduate science education -- give clear evidence of Foundation priorities. What is required is balance and commitment in this plan at least in principle.

The plan does not contain plain language. It uses key words without clarification. We can read into them things we hope for but that leads to wishful thinking. These words from NSF are elusive bonds easily slipped.

Thank you for the opportunity to express my views. The colleges I represent are grateful for your concern on these issues.

Sincerely,

Joan Straumanis
Dean of the Faculty
Rollins College
Winter Park, FL 32789

cc: The Honorable Sherwood L. Boehlert

Analysis of the Strategic Plan
for
Science and Engineering Education Activities
at
The National Science foundation

Prepared for

The Subcommittee on Science, Research and Technology
of
The Committee on Science, Space and Technology

U.S. House of Representatives

by

Bill G. Aldridge
Executive Director
National Science Teachers Association
1742 Connecticut Avenue
Washington, D.C. 20009

March 2, 1987

General Analysis of Plan

A careful reading of the updated Strategic Plan FY1987-FY1991 reveals little about NSF's future programming for Science and Engineering Education. The plans are stated in general terms or in reference to specific solicitations without reference to funding levels, number of funded projects involved, staffing required, timelines, or any other of the requisite components of a well-designed strategic plan. The plan, except for important omissions, describes in very general terms what all of us agree should be done, but not in any way that would lead to improved budgeting and detailed planning.

As NSTA President LeRoy Lee points out, "Its hard to disagree with specifics-because there are few. This sounds as if they are doing everything for everybody. The one major objection I have is the 'tone.' Last year they attempted to stress science for all students. That concept does NOT come through in this. It clearly reads as science to get more scientists and engineers."

Point-by-Point Analysis, with Recommendations.

The NSF Role

On pages 1 and 2 of the plan update, the NSF attempts to decide for itself which of the congressional authorization mandates it wants to follow. It is not the Foundations prerogative to make such decisions. The agencies authorizations are a responsibility of the Congress. Through input from all interested segments of the scientific and science education communities, and from the agency itself, congress has identified the role of the NSF in science and engineering education. The NSF has even prepared a document which summarizes its own statutory authority. Yet, as shown in the NSTA testimony of February 19, 1987, several important congressional mandates are being ignored or perverted.

The mission of the NSF at its inception was clearly a dual role involving research and science education. This dual role was reflected in the almost even division of funding in the early years between research and science education. The erosion of support for science education over the years has been directly related to the Foundation's dominance by the research community, ever anxious to have short-term gain in funding at the expense of the long-term scientific health of the nation.

Neither the Congress, nor the will of the American people have said that the Federal role in education was merely "catalytic", especially in areas where national security and competitiveness was crucial---as it is in science and engineering education. Nor has the congress said that the NSF responsibility was to provide "national leadership in education," a euphemism for "talk, study, and don't fund."

Recommendations

Congress should direct the NSF to use as a starting point for its five-year strategic plan for science and engineering education: 1. All of the detailed and specific authorization mandates which have been enacted by Congress and made Law; and 2. all conference report language concerning NSF authorizations, when such language provides greater detail and removes ambiguity. If deviations from authorizations are being considered by the NSF such deviations should be on the basis of advice from NSF's own science and engineering education advisory committee, and even then, only upon approval by Congress.

The Committee should ask the NSF to prepare the abovementioned mandate specifications as a starting point. This is the proper role of the National Science Foundation in Science and Engineering Education. Congress should require that this task be accomplished by no later than April 30, 1987.

When the NSF has a clearly detailed set of congressional mandates expressed in an organized and systematic way, they will form the basis of a strategic plan for science and engineering education. (I would suggest that those mandates are already quite clear, but are being ignored or perverted. Our testimony of February offers details of how this is being done.) These mandates constitute the mission of the NSF for science and engineering education, and its goals and specific program objectives must derive from these mandates, and not from the whims of the OMB or the dominant scientific research directorates of the NSF.

Local Control and NSF Support of Science and Engineering Education

On page two, the plan brings into play the old bugaboo of federal control coming with federal dollars. Yet the activities of the NSF in science and engineering education over the years have never imposed an element of federal control. Even the controversy over MACOS and a few other NSF supported curriculum development projects was the result more of the reaction of right-wing ideologues, than it was legitimate criticism. There is firm evidence that the curricula developed in the 60's have had a pervasive and beneficial effect on science education (James Shymansky, U. of Iowa, 1986).

The delivery of education is clearly a local responsibility in this country. The preparation of teachers is a state responsibility. When the local and state governments cannot or will not discharge this responsibility in areas of national interest, the federal government provides funds or programs. This has been true throughout the history of our nation.

Current Programming

There is a well-documented crisis in science and engineering education in this nation. It has several components: 1. the general public is scientifically and technologically illiterate in a period when such knowledge is essential to our national defense and competitiveness; 2. we have a system of education, incentives and support for the education of scientists and engineers which systematically discriminates against minorities and women. The imbalance of these groups within our scientific, technical, and engineering enterprise is so extreme that it is a national disgrace. The fact that minorities and women will make up two-thirds of our population in a decade or so requires a major effort to recover this enormous lost resource; 3. the massive infusion of foreign nationals into this nation's science and engineering graduate programs at colleges and universities, while the nation simultaneously undercuts support of its own citizens, especially among underrepresented groups, is a form of economic suicide.

More specifically, the precollege curricula of the 60's was designed mainly to prepare scientists and engineers. It needs major revision to address the needs of the general population and to appeal to women and minorities. Science and math teachers are being assigned classes for which they lack adequate preparation, and the NSF's programs for improvement of their background barely touches the problem. It is a badly underfunded band-aid approach. Undergraduate science and engineering education has suffered several years of neglect, as the NSF has concentrated its ever increasing resources on basic research. One need only refer to recommendations of NSF's own reports, studies, and advisory and task force reports to see detailed evidence of what is summarized in this paragraph. For the most part the congressional mandates for science and engineering education respond to these problems.

When it comes to the directly perceived interests of the research community, the NSF has no difficulty setting down the specifics needed for a strategic plan. The NSF gives specific numbers of fellowships or research assistantships, specifies how much each should receive, in what areas, and how they intend to move toward one graduate student for each principal investigator. What they fail to tell is that the bloated research budget at NSF increasingly is removing U.S. citizen principal investigators from college and university classrooms, so that instruction can be given by the huge influx of foreign nationals who are filling those graduate student slots, receiving U.S. financial support in the form of teaching assistantships and research assistantships from state and federal coffers (This was $159,975,000 in 1983; today such support is much greater).

Recommendations

The NSF should be directed to prepare detailed plans which address the documented problems in science and engineering education. The NSF should be asked again (as in Mr. Walgren's and Mr. Boehlert's letter of March 11, 1985) to prepare a detailed picture of resource allocation and expenditures for NSF's present science and engineering education effort. This should include specific program elements, numbers of proposals received, numbers of awards, amounts of awards, numbers of meritorious proposals not supported for lack of funds, numbers of teachers affected by teacher enhancement programs compared with the total teachers needing such programs, etc. The present status of science and engineering education programs at NSF should be clearly described in terms of resources and funding; then these efforts should be compared with the Congressional mandates, mission, goals and objectives developed in the manner previously recommended.

Strategies and Programs for the Future

Since this section, like the rest of the "strategic plan" lacks the necessary specificity to give any clear indication of where the NSF is going in its science and engineering activities, it needs major modification.

What are the specific program components, with subelemenents, for the next five years? How many of what kinds of projects will be supported, and how much will they cost? How many science and math teachers will be affected, and how much will be needed to do what is needed? Where will the science teachers, science education researchers, and teacher educators in science education come from over the next five years? How do these human resource projections relate to the nation's need for other scientifically and technically prepared personnel? What are the specific science and engineering needs of the lower division undergraduate programs and faculty in the nations two and four year colleges and universities? What programs address these needs, and how much will be required?

Recommendations

The NSF should submit to Congress as part of their strategic plan for science and engineering education detailed projections of program elements and subelements, with estimates of numbers of awards and average funding level, to include program element or subelement cost for each of the next five years. This projection should be reviewed and revised annually. Obviously, these programs should correlate with the Congressionally mandated mission and goals of the Foundation. The projections should show in cases of teacher enhancement activities the numbers of teachers affected and the costs per teacher. In cases of research, the number of awards planned in areas of greatest potential for new knowledge should be specified. For curriculum development, the plans should address the crucial problems at each level, and not delay solutions at one level under the excuse of using limited funds to phase up to higher levels, as called for in the present plan. We cannot wait for a generation to solve these problems.

Finally, the NSF should be directed to incorporate its science and engineering activities within the directorate for science and engineering education. Basic and applied research support is provided by the NSF to create new knowledge, not to interpret and impart that knowledge to others. To the extent that high school students, undergraduates, and graduate students can participate in the process of creating new knowledge, and learn to do research, there must be a relationship between the researcher and the student. That is precisely why the NSTA and other science and engineering education organizations strongly support NSF's role in these areas. But the education of scientists, as well as the education of the general population in science and technology, have no clear lines of demarcation, except as imposed, for example to limit the participation of minorities and women. The Foundation can easily organize and staff its science and engineering education directorate to meet the goals of producing an adequate supply of research scientists and engineers and to provide for the scientific and technical knowledge needed by the general population. The five-year strategic plan should detail how this will be accomplished.

APPENDIX 4

FOLLOW-UP QUESTIONS AND ANSWERS FROM THE NATIONAL SCIENCE FOUNDATION

Questions Submitted for the Record By Representative Doug Walgren

NSF BUDGET AND RESEARCH PRIORITIES

Question: Are there specific guidelines in place for the balance of funding between science and technology centers versus single investigator grants?

Answer: Yes. A long-standing National Science Board Policy (NSB-79-65) provides the policy framework within which decisions of this sort are to be made. In brief, the balance is to be struck within disciplines by full use of the various disciplinary advisory mechanisms which NSF utilizes. Major undertakings require explicit impact assessment, consideration of opportunity costs, and approval by NSB. In addition, every NSF program is subjected to formal assessment by an external committee of experts once every three years. The question of balance is a major consideration in these reviews.

An ad hoc NSB Committee on Centers and Individual Investigator Awards, chaired by NSB Vice-Chairman Charles E. Hess, is currently examining the relative merits of centers and individual investigator awards, including the matter of defining a proper balance. The committee's report should be in hand by mid-summer.

Question: What is NSF's policy for funding facilities, equipment and instrumentation? Is there a coordinated federal policy for funding research facilities? How does NSF's facilities, equipment and instrumentation policies differ from those of NIH, DOD, and USDA?

Answer: It is NSF policy to provide national or shared research facilities, whose use by scientists of a single institution would be uneconomical, in many areas of science and engineering, including physics, astronomy, atmospheric, earth, and ocean sciences, materials research, and computational science. In FY '86, about 13 percent of NSF's budget supported such facilities.

It is also NSF's policy to provide facilities support, if requested, in the framework of its regular research support/project grant activities, where so doing is deemed necessary to ensure the successful conduct of a meritorious research project. The FY '88 Budget request seeks to increase support for such disciplinary facilities.

In 1984, an ad hoc Interagency Steering Committee comprising NIH, DOE, DOD, USDA, and NSF examined the question of university research facilities, but no Federal policy exists per se for funding research facilities. Essentially, NSF provides those costly shared and national facilities necessary for maintaining the nation's basic research effort across a broad spectrum of disciplines, and the other agencies support those research facilities deemed necessary for the conduct of R&D in their mission areas.

In FY '86, equipment and instrumentation funding accounted for roughly 15 percent of NSF's R&D support, a significantly higher percentage than for other Federal agencies (DOD 10 percent, NIH 4 percent). NSF provides equipment and research instrumentation through three mechanisms: as part of research project grants (50 percent), through special instrumentation programs (25 percent), and by making them available in shared facilities (25 percent).

NSF's importance as a supporter of academic research equipment is twice that suggested by the share of total research funds it supplies: it provides roughly 10 percent of total academic research expenditures, but about 20 percent of total equipment dollars spent by universities and colleges. NSF intends to further increase its funding for research equipment and instrumentation in the years ahead, to continue its undergraduate instructional equipment program, and to start a Foundation-wide competitive initiative to provide for undergraduate instrumentation and laboratory development.

Question: Do you foresee problems in staffing NSF to manage a greatly increased budget? Is NSF experiencing any problems now in attracting well qualified scientists to manage the science and engineering programs?

Answer: We expect to be able to manage the enhanced NSF programs with only small increases in staff. However, we are experiencing some problems in attracting and retaining well qualified scientists to manage programs. Further, we expect continued difficulties since Federal employment is increasingly unattractive relative to the academic environment. This is largely due to an imbalance between academic and government salaries and a reluctance on the part of high-caliber individuals to leave research posts for Federal employment.

NSF is continuing to explore every reasonable approach to address recruiting problems and obtain highly qualified staff. We are using NSF excepted appointment authority to allow "rotators" to take 1- or 2-year leaves of absence from their academic institutions to work as NSF employees. In addition, through the Intergovernmental Personnel Act, we are able to bring a select number of expert scientists and engineers on details to NSF, while allowing them to remain employees of their universities and continuing to receive their academic salaries and benefits, even if higher than government compensation.

Question: NSF was created to fill the basic research gap not addressed by mission agencies and to provide for high-risk, high-potential basic research at the cutting edge of science.

As NSF's budget increases, the support for basic research in some mission agencies such as DOE, DOD, and NOAA appears to decrease. What do you feel is the long-range effect of this trend? If the trend continues, will the original function of NSF also be changing? Do you feel the present NSF Organic Act supports such change?

Answer: Special Analysis K of the 1987 Budget to Congress and Special Analysis J of the FY 1988 Budget to Congress (Tables K-3 and J-3) show trends for increases for the National Science Foundation, the Department of Energy and NASA. The Department of Commerce remains fairly constant, while Defense basic research funding declines.

Increases in the NSF budget may be a partial response to under-investment by other agencies, but it is not a cause of it. There is a tendency for mission agencies to underfund basic research when there is pressure on their overall budgets, and to emphasize demonstration projects and development which are more easily tied to mission needs and objectives. NSF has expressed concern about this tendency, and has strongly urged increased investment in basic research, especially in universities, by Federal mission agencies.

The NSF Organic Act was broadly drawn and allows the agency to adapt to changing circumstances, including shifts in the funding patterns of other agencies. However, NSF believes that the health of the Nation's research enterprise is best served by diversity and balance, characteristics which are enhanced by the meaningful participation of mission agencies in both the conduct and support of basic research.

Question: What role does OSTP (Office of Science and Technology Policy) play in planning and coordinating the total federal basic research program?

Answer: OSTP has traditionally assessed policy across the agencies, endorsed and instigated new and future developments, and advised the President on national science policy. OSTP helps to formulate national plans for science and engineering as, for example, in the White House Science Council report (Packard-Bromley) of 1986.

OSTP has interacted with specific agencies and OMB to plan for future science activities such as the planetary science missions at NASA, the Superconducting Super Collider (SSC) at the Department of Energy, and the Administration's proposal to double NSF's budget over the next five years.

OSTP also coordinates national science activities to maintain awareness in the Executive Office of the President on science issues of regional, national and international importance, such as depletion of atmospheric ozone, increasing carbon dioxide and other gases and their impacts on the greenhouse effect, acid rain, biotechnology issues, and the like.

Question: The NSF Global Geosciences initiative depends on remote sensing contributions from NASA and data management responsibilities from NOAA. How adequately have NASA and NOAA contributed resources to the Global Geosciences program? Has NSF had to make any changes in their plans based on budgetary reductions of other agencies?

Answer: The NSF Global Geosciences initiative consists of multidisciplinary programs whose goal is to provide understanding of coupled earth systems. Several of the programs in this initiative will integrate remote-sensing data from satellites (scheduled for launch in the early 1990's) in order to provide global-synoptic data bases. Both NASA and NOAA have programs which complement the NSF Global Geosciences program, such as study of the ozone depletion problem and the Tropical Ocean Global Atmosphere program. Other agencies have programs as well. With the availability of such data, NSF-sponsored research will undergo a concurrent phase of intensive in-situ measurements in order to calibrate and validate the space-based observations.

NSF has made no changes in its Global Geosciences initiative as a result of budgetary changes of other agencies. Although no other federal agency provides direct financial support for the Global Geosciences initiative, NSF has planned, and will continue to plan with other agencies in formulating a national effort in this research area.

Question: If the NSF budget grows at the rate proposed for the next few years, do you believe that it will be necessary to institute the Office of Inspector General? If so, what time frame do you have in mind?

Answer: The NSF Division of Audit and Oversight, which has been in existence for almost a decade, functions as our office of inspector general; no change is currently anticipated. The portion of our resources devoted to this function is reexamined annually in the light of demands placed on this activity by the type and scale of our programs.

Question: Researchers have complained that principal investigator (PI) awards are too small. Are there plans to increase award size? How great a priority is that? Would it take precedence, for example, over opening more centers?

Answer: One area of emphasis across all NSF activities continues to be to redress inadequate award size. Several activities are already in place to begin to focus resources on this problem. Emphasis on graduate student and postdoctoral student support will provide much needed long-term commitment to research programs and thesis problems of post-graduates. Research Experiences for Undergraduates will not only bring more students into the research environment to learn first-hand the scientific experience, but will also provide personnel to research efforts. Instrumentation needs are being redressed across all the disciplines, particularly in BBS fields.

Increasing award size will continue to be a priority. But that priority will be balanced with areas of equal importance such as ensuring broadened participation by women and under-represented groups, fostering group research efforts, as well as beginning new centers of scientific and engineering research.

Question: What was NSF's original request to OMB for the FY 88 budget? Please provide details at the directorate level. How did the OMB pass back compare to the original request, as well as to the final FY 88 Presidential request?

Answer: The request and passback are detailed on the attached chart. The OMB passback did not address Directorate (activity) or program funding levels within any of the appropriation accounts.

The only express directives or limits in the passback were the addition of funds to the U.S. Antarctic Program for a research vessel with icebreaking capabilities and a limit on Full Time Equivalent employment of 1204.

NATIONAL SCIENCE FOUNDATION
COMPARISON OF FY 1988 OMB REQUEST
TO THE PRESIDENTIAL REQUEST/OMB PASSBACK
(Dollars in Thousands)

	FY 1988 NSF Request	FY 1988 Presidential Request/OMB Passback	Difference Cong/OMB
Mathematical and Physical Science	$638,500		
Engineering	269,000		
Biological Behavioral and Social Sciences	362,330		
Geosciences	394,000		
Computer and Information Science and Engineering	190,000		
Scientific, Technological, and International Affairs	64,500		
Program Development and Management	93,920		
Subtotal, Research and Related Activities	2,012,250	1,635,000	(377,250)
U.S. Antarctic Programs*	130,000	143,000	13,000*
Science and Engineering Education	133,000	115,000	(18,000)
Special Foreign Currency	0	0	0
Total, National Science Foundation	$2,275,250	$1,893,000	($382,250)

*Additional funds specifically provided for lease and outfit of ice-breaking research vessel.

ADVANCED SCIENTIFIC COMPUTING

Question: Two major goals in establishing the supercomputer centers were to train new users and generally to provide wide access to university research scientists. To the extent the goals are met, do you envision an accelerating demand for supercomputer cycles?

Answer: Yes, we believe that as the research community gains experience and the utility of these machines is widely demonstrated that there will be increased demand for very high performance computers of all classes, from the emerging less expensive class of mini-supers to the next generation of machines at the highest end of the performance range.

Question: Does NSF have a forecast of supercomputer demand for the next five years?

Answer: There is no accurate way to forecast supercomputer demand in the next five years. With our recent past experience as a guide, we expect it to continue to rise rapidly. In 1984, the requests for supercomputer time totalled about 5000 hours; in 1987, we expect to allocate about 150,000 hours. To an extent availability creates demand. Every increment in computer performance allows more complex and sophisticated problems to be solved, and as new research vistas are opened, new requirements are created.

Question: Will NSF centers and other university supercomputers meet the demand?

Answer: If the budget is sufficient to permit NSF to fund replacements and upgrades to new machines, some of the demand will be met by upgrading the NSF center supercomputers to the next generation, which will become available in the next 2 years. Also NSF's support of supercomputing has spawned university investment in supercomputing capability. If the cost of this technology continues to decrease, as is anticipated, it is expected that the university base of supercomputing will grow.

Question: How will computer time at non-NSF supercomputers be paid for?

Answer: Supercomputers outside the NSF Centers are supported by other sources, such as other agency grants, local and state governments, and sale of time to industrial concerns. In addition, funds from other parts of NSF (outside the Division of Advanced Scientific Computing) may be made available on standard grants. We have no policy preventing awards from the research programs for that use, and with growing use of supercomputing, we expect it will happen. At present, NSF focuses its own effort on the Centers to build them up to truly unique national resources.

Question: What is your view of the evolution and lifetime of Phase II Centers?

Answer: The Phase II Centers are evolving into centers which provide leadership in computational science and engineering, and state-of-the-art resources which are not available at the non-NSF centers. The initial commitment of NSF to the centers program is for a period of five years. After they have had sufficient time to establish and prove themselves, the need for the centers will be reevaluated. We anticipate a need for unique services of the type provided by the Phase II Centers to continue in the foreseeable future.

Question: Does NSF plan to meet the funding levels negotiated with the Phase II Centers in Fiscal Year 1988 and beyond?

Answer: In 1985, when the Phase II centers were started, funding levels were negotiated and agreed to in the cooperative agreement documents. For four of the centers, these levels were projected for five years. We have fulfilled each of the agreements consistent with the performance of the center. That is, reductions were made only where expected acquisitions were delayed (John Von Neuman Center) or where levels of expected activity rose more slowly than anticipated (Cornell). In Fiscal Year 1988, therefore, there are agreed-to levels of funding for four centers, and for Cornell.

Question: One of the key questions in managing the distribution of supercomputer resources is the decision of how to allocate available computer cycles among competing scientific disciplines.

How is it currently being handled?

Answer: The allocation of supercomputer cycles at the NSF sponsored centers is done through the peer review process. There are currently two levels of review. One is by the regular NSF programs, using their usual mechanisms of peer review, and the other is through multi-disciplinary panels which meet several times a year at each of the centers. The reviewers are asked to evaluate the quality of the science to be accomplished through the use of the supercomputer, and also whether the approach proposed is appropriate for the use of a supercomputer.

Question: Is the system flexible enough to allow resources to flow toward disciplines for which it becomes clear that progress is closely linked to substantial use of supercomputers?

Answer: Every effort is expended to keep the allocation process as flexible as possible. We are committed to a system which will maintain a proper balance between disciplines without the arbitrary imposition of rigid quotas. Those disciplines which require supercomputers in order to make progress will be given high priority.

Question: Current decisions regarding technologies, standards and protocols will impact the future configuration of the proposed national scientific computer network. It is essential that tight management control and careful coordination with all categories of potential users be exercised.

Answer: NSF began its network activity to provide access to supercomputers, and that remains the major focus of the effort. However, we believe that the national scientific computer network has importance well beyond serving supercomputer users, and have begun organizing to serve the other 90% of the scientific and engineering research community. Through our newly established Division of Networking Research and Infrastructure (which has been elevated from its former program status in the Division of Advanced Scientific Computing), the Foundation participates through a nominated representative agent and via a new research program in the current transitional stages of study and modification of the networking protocols proposed by the International Standards Organization (ISO), to which the NSF and the nation are committed. NSF grantees are experimenting with the ISO protocols and, together with participants from the private industrial sector, are devising ways both to ease the transition as well as to cope with the expected differences among different national realizations of the protocols.

During the past year, the Foundation engaged in a series of informal technology forecasting and planning sessions in preparation for its role in the study mandated by Section 10 of the FY 1987 NSF Authorization Act (OSTP networking study) and in various Federal Coordinating Committee on Science, Engineering and Technology (FCCSET) committees. The plans and forecasts which resulted from these sessions are in substantial accord with the recommendations which emerged from OSTP study panels, although there are differences in detail and timetable.

In brief, the plan, which the Foundation has begun to implement has two components. In the first, full deployment of NSFNET and other agency research-support networks continues, accompanied by a deliberate program of close interagency collaboration so that the joint deployment can stretch the current technology to its feasible limits to achieve the best interim performance at the least possible cost. The second component of the plan requires the immediate initiation of a focussed program of research, exploratory development, and pilot demonstration projects which will lead within a decade to a national interagency research network with high capacity and very high speeds matched to the expected requirements of the research community in the twenty-first century. A proposal aligned with this second component has recently been received by the Foundation. Submitted by a not-for-profit private organization, the proposal is a cooperative effort involving academic institutions, major computer manufacturers and telecommunication research laboratories. Assuming survival by merit review and availability of funds, the coordinated program described in the proposal will demonstrate a pilot network operating in the gigabit-per-second speed range over optical fibre within a very few years.

Coordination of networking plans and policies with the widest possible spectrum of scientific users is being ensured by both formal and informal means. The principal formal step taken was to form a joint Program Advisory Panel for the Division of Advanced Scientific Computing and the Division of Networking and Communication Research and Infrastructure.

Question: Is the NSF budget request for networking consistent with the scope of the problem?

Answer: There are four components considered in the NSFNET budget request: 1) continued deployment of already-approved regional networks according to each approved proposal's planned schedule; 2) acquisition of professional, private-sector management for the current NSFNET; 3) interagency collaboration to fully deploy the current NSFNET at the limits of current technology; and, 4) the exploratory development and pilot demonstration project for the network of the future, as outlined above.

Items 1 and 2 can be funded at the present budget level. We have allocated some resources to item 3 by stretching out the deployment of regional networks.

Question: Does NSF have funding estimates for creating the proposed national scientific computer network?

Answer: Yes, but only preliminary ones. A funding profile for the gigabit-per-second national interagency network is under development in an OSTP study. To obtain precise estimates will require an engineering design. We will provide the Committee with the results of this study when they become available.

It should be emphasized that this projected annual operating cost is highly dependent on the telecommunications tariff schedules for very high bandwidth circuits; these schedules were developed with the concentration of voice traffic primarily in mind, and may not be appropriate for high bandwidth digital computer-to-computer applications. The next phase of the OSTP study is to explore the cooperation of industry in establishing such a network.

Question: Once created, what would NSF's role be in maintaining it?

Answer: The role of NSF and other participating Federal agencies will be to oversee the operations of the management organization through membership, along with representatives of the user community, in a Board of Governors.

Question: Are all of the regional networks which are now appearing in conformity with some overall plan?

Answer: The plan for regional networks, and for other networks affiliating with NSFNET, has two stages. The first stage comprises full deployment of the networks as proposed and approved under merit review, exploiting to the utmost the energy, synergy, cooperative spirit and opportunities for cost-sharing which give the regional network program its strength and essential impetus. As installation of the networks nears completion, the second stage of the plan will involve negotiation to rearrange regional affiliations as necessary to lower costs while retaining or improving performance. Thus, there may be eventual amalgamation of smaller regions into larger entities to achieve critical mass of scarce networking talent and other resources, and to achieve economies of scale. Some administrative changes may also ensue, to identify particular sub-organizations (e.g., state networks) in order to improve their sense of identity and enhance the prospects for non-Federal support. This is naturally contingent on the actual development of the network plan.

Several regional networks have been funded within the last year. Some parts of them are now in operation. They all use standard protocols, and are connected in an optimum fashion to the NSF backbone network. The overall plan is to provide supercomputer access and communications ability to all the major research institutions in the country, in the most cost-effective way consistent with providing a state-of-the-art resource.

Question: NSF has been involved in support of university supercomputer centers for about three years.

When will an assessment be made of the impact of these centers on science?

Answer: The impact of the NSF supercomputer programs on the progress of research in science and engineering is an important factor in the decision of whether to continue funding of these programs. We therefore plan to conduct an assessment of this impact on several levels during the next year.

Question: Who will conduct these assessments and what criteria will be used?

Answer: The Federal Coordinating Committee on Science, Engineering and Technology (FCCSET) is currently conducting a study of the scientific impact of all federal supercomputer centers. Also, the NSF Office of Budget, Audit, and Control has a study under way. We are also exploring mechanisms through the NSF research programs and their advisory committees to evaluate the impact for individual disciplines.

Scientific impact is one of the major criteria for the evaluation carried out through the merit review process. Each NSF-sponsored supercomputer center is reviewed annually by a site visit team of outside experts. Their reports give us an estimate of the importance of these centers to the national research endeavor.

Question: If the examination findings are favorable, will NSF continue funding and possibly increase the number of centers or significantly increase funding for existing centers?

Answer: If the results of assessments are favorable, and the supercomputer needs of the community are not being met by other sources, then NSF intends to continue funding of the present centers. There are at present no plans for increasing the number of centers. We plan to use the national scientific research network to increase access and possibly to pool resources (including non-NSF supported resources). If it appeared necessary in the future to increase capacity, we would have to consider the trade-off between starting new centers and increasing the capacity at the existing centers. We believe that the ever changing nature of the advanced computing environment demands this type of flexibility.

Question: In the report accompanying the FY 1987 Authorization Act, NSF was asked to take the lead role in implementing a federal interagency follow-up to the 1982 Lax Report on large scale computing.

What action has NSF taken to implement this recommendation?

Answer: In February, NSF organized and co-sponsored with the Department of Energy, a workshop on the present state and future plans of advanced computing. Part of the report of this workshop will be a follow-up to the 1982 Lax report. The workshop participants were asked to consider the question of whether the recommendations of the Lax report have been carried out, what remains to be done, and what the federal role should be in the future.

Besides the NSF and DOE, representatives of several other Federal agencies participated in the February workshop. These included NASA, several parts of the DOD, and NIH. The rest of the research community was represented by experts from universities, industries and government laboratories. The report of this workshop, which should give us valuable advice on for future planning, will be available sometime within the next few months.

NSF PERSONNEL

Question: I understand that in the next few months, two Assistant Directors and four of the five Division Directors of the Mathematical and Physical Sciences Directorate will be leaving NSF.

What has the trend in personnel turnover rate been in the last three years?

How does the use of rotators, limited term and Intergovernmental Personnel Act appointments, affect the turnover rate?

How many of the eight Assistant Directors are appointed on a short or limited term basis and how many of those will be leaving NSF before the close of FY 1987?

Answer: We normally consider turnover to be the total number of voluntary separations divided by the average number of workers employed during the period. Voluntary separations include retirements, resignations, and transfers to other Federal agencies. However, temporary employees such as IPA's and rotators are not normally included in these turnover calculations since separation of these individuals after a specified of employment is a planned action.

Turnover rates during the past three fiscal years are approximately 2 to 3 percent greater if the temporary employees and IPA appointments are considered in the equation. These rates are as follows:

Turnover Rates

Year	Excluding IPA & Rotators	Including IPA & Rotators
FY83	14.0%	17.0%
FY84	12.8%	14.2%
FY85	14.6%	16.5%
FY86	12.4%	15.7%

Of the eight NSF Assistant Directors, three (ADM, STIA, and MPS) are filled by career SES appointees, three (BBS, CISE, and SEE) by SES limited term appointment, and two (ENG and GEO) detailed through the provisions of the Intergovernmental Personnel Act (IPA). The Assistant Directors with Limited Term SES appointments or under IPA detail follow:

Incumbent	Directorate	End of Appointment/Detail Current	 Maximum*
C. Gordon Bell	CISE	06/16/89	06/16/89
David T. Kingsbury	BBS	11/02/89	11/02/89
William J. Merrell (IPA)	GEO	09/30/87	10/16/90
Bassam Z. Shakhashiri	SEE	06/25/87	06/25/87
Nam P. Suh (IPA)	ENG	09/14/87	09/14/90

* Limited Term SES appointments may be extended for a maximum of three years; IPA details for a maximum of four years.

Question: Have you begun the competitive recruitment process to fill the Assistant Director positions which are to be vacated in FY 1987?

Answer: Competitive recruitment procedures have been initiated for the Assistant Director positions in BBS and SEE. Discussions are underway concerning the intentions of the Assistant Directors of GEO and ENG. Should the NSF, the home institution, and the incumbent concur the IPA detail could be extended. If this is not agreed to, recruitment efforts will begin immediately to fill these positions.

RESEARCH CENTERS

Question: The NSF budget request proposes "establishing science and technology centers in all disciplines, because of the key role such university-based centers can have in stimulating economic competitiveness." What criteria would you use to evaluate the centers' contribution to economic competitiveness?

Answer: There is widespread agreement that support of basic research in universities is an effective method of enhancing the science base for industrial innovation. The payoff occurs primarily in improved efficiency of the R & D process and in major technological changes which permit continued improvements in economic productivity over the long term.

It takes long periods of time for research progress to result in industrial innovation. There are frequently multiple paths of activity leading to an innovation, and the process is frequently not straightforward. There are overlaps, gaps, and skips. Measurement, accordingly, is uncommonly difficult.

The two main modes of transfer of basic research results are information transfer through publications and reports, and the education of scientists and engineers. Indeed, many students of innovation think education is a principal mechanism, both through the movement of new graduates into industry and the professional linkages of scientists and engineers in industry. The role of sensitizing academic researchers to the needs of industrial researchers is also considered to be important to information transfer efficiency.

It is, accordingly, in the area of "embodied" information that the centers will be evaluated. While technical publications and concrete innovations will be evaluation factors, greater emphasis will be placed in the near term on assessing the participation and circulation of both graduate students and industry scientists/engineers in terms of numbers, turn-over rate, disciplines, and industry sectors. Also, an indicator of the value of the centers to industry will be industry's willingness to contribute to them, an additional assessment factor.

Question: Advancements in manufacturing technologies will be a key factor in improving our industrial competitiveness. Do you feel that the importance of manufacturing research is reflected in the proposed fiscal year 1988 NSF budget?

Answer: The importance of manufacturing research to NSF is reflected in our proposed budget for FY 1988. About $50 million is planned for research on issues directly related to manufacturing, an increase of about 40 percent over the previous year. Research activities most relevant to this effort are:

- Engineering Research Centers (ERC) program, was designed to promote research that will ultimately support U.S. economic competitiveness. Fields selected for funding are at the leading edge of many expanding technology areas. About a third of the $48 million requested in FY 1988 for the ERC program will support centers focusing on some aspect of manufacturing research. Of the 11 ERC's already funded by NSF, six with manufacturing research components are:
    - Carnegie-Mellon University -- Engineering Design
    - University of Delaware/Rutgers -- Composites Manufacturing
    - University of Maryland/Harvard U. -- Systems Research
    - Ohio State University -- Net Shape Manufacturing
    - Purdue University -- Intelligent Manufacturing Systems
    - U. Cal./Santa Barbara-- Robotic Systems in Microelectronics

- Design, Manufacturing and Computer-Integrated Engineering Subactivity, which increases by 28 percent in FY 1988 to $18 million. This reflects the increased emphasis NSF has placed on research in engineering design, automation and manufacturing. The integration of these fields aims to improve U.S. manufacturing industries' productivity and economic competitiveness. The main goals of the research consist of:
    - Gaining a basic understanding of the primary physical processes in manufacturing, and creating new machines to implement these processes efficiently;
    - Solving the systems problems necessary to make autonomous machines, such as robots, operate in an automated, integrated system environment; and
    - Establishing new design methodologies and principles of engineering design.

Question: NSF Engineering Research Centers (ERC) have been established to help forge closer ties between university researchers and industrial needs.

To what extent does NSF target support for Centers that have particular relevance to specific industries judged either to require special help or to have special promise for growth?

Answer: During the first three ERC proposal competitions (FY 1985 through FY 1987), NSF decided not to target specific industries or research areas, mainly to remain as open as possible to the best ideas coming from the research community. The process inherent in preparing an ERC proposal focuses on issues critical to technological advancement because the academic team will seek industrial guidance and support in preparing a highly qualified proposal. In addition, the ERC review process uses both industrial and academic personnel. Reviewers may consider factors such as industrial growth potential or need for assistance in the competition.

Beginning with the FY 1988 competition, the ERC program announcement will include a non-exhaustive list of generic topic areas of potentially wide impact where NSF believes there is a need for centers. This list is not now complete; some likely inclusions are:

- Design and Manufacturing
- Advanced Materials Processing
- Surface and Interfacial Technologies
- Resource Recovery and Utilization
- Emerging Technologies such as Neuroengineering, Biotechnology, Lightwave Technology, and Optoelectronic/ Mechanical Devices and Systems

The topics are generic areas of research which would impact a wide range of traditional and emerging industries.

Question: What criteria will be used to evaluate the effectiveness of a Center?

Answer: The ERCs operate under a five-year cooperative agreement with NSF. Each year the ERC program reviews the progress and plans of each center. Information gained during this review is used to determine annual refunding levels for each center. Currently, one of the key factors in that decision, given sufficient progress in meeting the goals of the center, is the level of industrial support.

The program will review the center during its third year of operation to determine whether NSF will make a new five-year award (beginning in its fourth year) or decrease the funding to phase out the center at the end of its fifth year.

The proposed criteria to be used during this third year evaluation were developed from the key objectives of an ERC. NSF sought the independent advice of the National Research Council on the criteria, measures, and procedures for this evaluation. Examples of the criteria follow:

- The center has successfully met its proposed goals and the goals of NSF's ERC program.
- Under effective leadership and management, the center has vision and a strategic plan to carry out that vision.
- High quality, cutting edge research in thrust areas relevant to technological advancement and competitiveness has been achieved through a focused and integrated set of projects.
- The structure of the center encourages cross-disciplinary research.
- The research is integrated into the educational/curriculum development activities and undergraduates as well as graduate students are involved in research projects.
- There is an open, interactive dialogue with industry and a sufficient and expanding base of industrial support.
- The center has effective leadership and management.

The specific measures and data used to assess the degree of success in achieving these criteria are gathered from the ERC's annual reports, site visits, and annual submissions of data on progress and activities.

Question: NSF has supported Material Research Laboratories at universities for about 15 years. What criteria have evolved for evaluating the performance of these multi-disciplinary research enterprises?

Answer: NSF assumed responsibility for the Materials Research Laboratory (MRL) program in 1972.

MRL's undertake research in materials science and engineering of a scope or complexity not feasible under traditional funding of individual research projects. Essential activities include:

- Thrust area research. (Major research programs on materials problems requiring sustained, cooperative effort by several investigators with diverse backgrounds).

- Development and operation of central research facilities.

- Seed funding for new concepts and ideas.

Local management: each MRL has express authority to manage its own operation with respect to program administration, planning, content and direction. Overall program balance is effected through continuing discussion between NSF and local MRL management.

FY 1985 there were 14 MRL's. Five of these are now being phased out in order to strengthen the remaining nine.

Each MRL is evaluated every three years (more frequently if necessary) by merit review based on a written renewal proposal and a site visit. Mail reviewers and site visitors are selected from university, government and industrial laboratories.

Reviewers are asked to evaluate an MRL renewal proposal (or a proposal to establish a new MRL) in two ways:

Each thrust area in the MRL is reviewed in terms of

- Quality of research
- Significance of research
- Resources (faculty, facilities and institutional setting)

and, because it is located in an MRL,

- Degree of interconnection (benefits as a multi-investigator thrust; cooperation and interdependence of the investigators).

The MRL as a whole is then evaluated in terms of

- Selection and implementation of research efforts
- Relation of research program to current and future needs
- Overall direction of the laboratory
- Operation of central facilities
- Introduction of new research initiatives.

Question: With the proposal to establish 10-15 new science and technology centers in FY 1988, has any thought been given to a science education research center? What areas of science education research should be given priority and lend themselves to your criteria for establishing science centers?

Answer: The proposed Minority Resource Centers reflect the Foundation's priority for centers in science and engineering education. These comprehensive centers will address the critical need to strengthen institutional capabilities to increase the participation of minorities in science and engineering. Programs for minority institutions were a primary recommendation in the National Science Board report on undergraduate science, mathematics and engineering education.

In addition, concern for education is a key element in the proposed Science and Technology Centers. The centers' contribution to education, including precollege, undergraduate, graduate and post graduate education, is an issue under active consideration as specific center guidelines are being developed.

Other areas of education research are supported through grants in the research in teaching and learning activity. Areas identified for attention include instruction and learning in specific disciplines; the effect of teacher cognition on teaching performance; factors that influence instruction and student participation and achievement at various ages; and the significance of first-hand observation and experience (laboratory experience) in the learning process.

Question: Some researchers claim that the Engineering Research Center program is so focused on short-term, high tech, industry support research that it is now easier to get funding for some types of basic research from the Department of Energy than from NSF. Could you respond to that assertion?

Answer: Due to the uniqueness of the Engineering Research Centers program, NSF's annual program announcement has generated many more proposals than normal. The success ratio for the ERC program averages about four percent, which gives the perception of harder funding than in other agencies, such as DOE.

One of the goals of the Engineering Research Centers is to support fundamental research critical to long-term economic competitiveness. Such research focuses on the understanding and advancement of a technological system. Thus, the centers support both fundamental research and research focused on moving the knowledge to a proof-of-concept stage for a new device or process.

However, the research underway is not short-term and is not focused on the needs of a specific industrial firm. Because the ERCs bring together a group of firms which act in concert to advise the centers, the research is necessarily generic.

Question: NSF's proposed Science and Technology Centers are a major Presidential initiative. What areas will they concentrate on? Will applications be solicited in special fields or will the solicitation be more general? Will more such centers be established in future years? How will the program differ from the Engineering Research Center program?

Answer: The Centers program, as detailed in the FY 1988 Budget to Congress, will begin in a few selected disciplines across NSF, notably Biological Research Centers in BBS, Neuroscience Research Centers, a National Center for Geographic Information and Decision, Risk and Management Science Centers in Social and Economic Science, Interface Science and Engineering in Chemistry and Material Research, Accelerator Mass Spectrometry Center as well as Minority Centers in Geosciences, Minority Research Centers of Excellence in STIA, and Resource Centers in SEE are the major new areas supported in FY 1987 and planned for FY 1988.

NSF currently plans to issue a general solicitation for S&T centers in FY 1988; we can not know in advance what areas of research will be proposed. However, NSF has asked the National Academy of Sciences to convene an ad hoc policy group to address several issues, including:

- What are the most promising areas of science where these centers can make a significant difference?
- What are the defining characteristics of science and technology centers, and how do these characteristics relate to economic competitiveness?
- Since industry and state participation is a prerequisite, what form should this participation take and how is it best utilized?
- What support is required and over what period of time?
- Ground rules for the solicitation.

- Monitoring mechanisms and sunset rules.

- The centers contribution to education, including precollege, undergraduate, graduate and postgraduate education.

- Governance of the centers.

NSF has asked for a report in June 1987.

The form and content of the centers will probably be as different and diverse as the disciplines that NSF supports. Certainly, the ERC's present a first model upon which to build future centers. But, as with any first time experience, NSF intends to employ the lessons learned soliciting, reviewing, and funding the ERC's, as new centers are proposed.

Question: What steps, if any, could be taken to increase industry support of NSF programs, particularly the supercomputer centers?

Answer: NSF has been increasing its cost sharing programs with industry in several disciplines. In particular, industry support of the NSF supercomputer centers and the Engineering Research Centers form an important component in the overall strategy of funding such centers. The mechanisms with which we encourage, or in some cases, require cost sharing include, but are not limited to the following:

- Industry funded collaborative research projects through increased interaction between supercomputer centers' staff and potential industrial collaborators.

- Centers seek grants or discounts from supercomputer vendors.

- The Engineering Research Centers awards are partly based on the amount of industry support (as well as high quality research potential), with follow-on funding also partly dependent on increased industrial support.

- Increase more matching funds programs, such as the successful Presidential Young Investigators (PYI) program.

SCIENCE AND ENGINEERING EDUCATION

Question: What was NSF's original request to OMB for the FY 1988 budget for the SEE Directorate?

Of this amount, how much was for support of precollege science and mathematics education?

Answer: NSF's original request for SEE in FY 1988 was $133 million. Of this amount, $73 million was for science and mathematics education at the precollege level.

Question: Could you elaborate on your plans for establishing an Office of Undergraduate Education in the SEE Directorate?

How will you assure that the funds in the other Directorate will actually be spent for science education?

Please provide for the record, the funding level each Directorate will contribute to science education in the proposed FY 1988 request.

Answer: We presently are studying appropriate potential roles, functions, staffing levels, and other matters related to the Office of Undergraduate Science, Mathematics, and Engineering Education in SEE.

One function of the Office will be to coordinate undergraduate educational activities across the Foundation and assist the other directorates with their undergraduate activities. The Office will track and monitor undergraduate activities and provide periodic reports. The Foundation has developed a coding and accounting system which assures that funds designated within each directorate for undergraduate education are spent for that purpose.

Planning estimates based on the Foundation's FY 1988 budget request include the following levels of undergraduate activity in each directorate:

Mathematical and Physical Sciences	$15.8 million
Engineering	10.2
Biological, Behavioral and Social Sciences	14.7
Geosciences	9.8
Computer and Information Science and Engineering	5.0
Science and Engineering Education	12.5
Scientific, Technological and International Affairs	-
Total	$68.0 million

In addition, several comprehensive activities for developing human resources will include activities at the undergraduate level -- for example Minority Resource Centers in SEE and Research Career Opportunities in STIA.

Question: The NSF budget request for Teacher Preparation and Enhancement, states, "A portion of the funds ($36.0 million) in this component is used to support targeted proposal solicitations." What portion of the funds were used for targeted solicitations in FY 1987 and what were the specific targeted areas?

Is the targeted solicitation used in any other Subactivity in the Science and Engineering Education Directorate?

Answer: One solicitation issued by the Teacher Preparation and Enhancement Subactivity, "Programs for Preparing Middle School Science and Mathematics Teachers" (NSF 85-67), resulted in nine awards in FY 1987 for $1.8 million. These awards represent 6.0% of the subactivity ($30.5 million) in FY 1987.

Targeted solicitations were also used in the Materials Development, Research and Informal Science Education Subactivity. Targets and expenditures in FY 1986 and FY 1987 were as follows:

FY 86:	Elementary School Mathematics	$2.6 M
FY 87:	Elementary School Science	$2.5 M

In addition, this subactivity has issued an additional solicitation targeted on Elementary School Science.

Finally, the Directorate at large has issued a solicitation targeted on Private Sector Partnerships to encourage partnerships between business, industry, local school systems, colleges and universities. The Directorate anticipates funding five to twelve projects for a two to three year period, with a total investment of $2 - $4 million.

Question: The FY 1988 Budget proposal includes $36.0 million for the Teacher Preparation and Enhancement activities.

What part of this supports summer institutes?

Answer: Of the $36.0 million budgeted for Teacher Preparation and Enhancement in FY 1988, $22.3 million has been allocated for Teacher Enhancement projects. These funds support precollege teacher institutes and related activities. In addition, $3.0 million is budgeted for Undergraduate Faculty Development and $2.5 million is budgeted for career access projects. Both of these programs will feature institutes for college teachers; the latter will focus largely on teachers from predominantly minority institutions.

Question: Could you provide a picture of the way in which this program is carried out?

Answer: The Teacher Enhancement Program invites proposals through a widely distributed Program Announcement (NSF 87-10). About 500 proposals requesting a total of approximately $100 million are received each year, most from colleges, universities, and school districts. Proposals are reviewed following standard Foundation procedures for merit review. Ad hoc review panels include professors of science and mathematics, representatives from university education departments, precollege school teachers and administrators, state department of education personnel, and research scientists from government, industrial, and nonprofit laboratories. For each proposal, at least five reviewers prepare detailed reviews, and then consult with each other to arrive at a consensus recommendation. NSF program officers then prepare award recommendations. The entire process takes four to six months.

Question: In 1986 and in the plan for 1987, fewer than 50 states have teacher training institutes. Did any organizations in the states not represented submit proposals?

Answer: In FY 1986, 20 organizations in seven states not represented submitted proposals. Each of these proposals was judged to lack adequate merit by the reviewers and by the responsible NSF program officer and supervisors.

Question: Were the NSF awards made in conformity with the provisions of Public Law 99-159 (NSF Authorization for FY 1986)?

Answer: The awards were made in conformity with the provisions of Public Law 99-159. The six awards made in FY 1986 which exceeded $300,000 all include "the services or resources of more than two entities in the design and operation of the institute," in conformity with the requirements of Section 103 (c), 20 U.S.C. 3913.

Question: Could you provide for the record the geographic distribution of these activities?

Answer: The following list shows teacher institutes operating in FY 1986:

TEACHER INSTITUTES

ALABAMA	1	$ 46,056
ARIZONA	2	324,509
ARKANSAS	2	193,231
CALIFORNIA	18	3,832,670
COLORADO	5	843,959
CONNECTICUT	1	265,608
DELAWARE	1	108,629
DIST OF COL.	7	1,053,284
FLORIDA	2	139,753
GEORGIA	1	74,177
HAWAII	1	130,971
IDAHO	1	47,264
ILLINOIS	8	1,651,489
INDIANA	4	444,005
IOWA	5	1,108,303
KANSAS	4	661,577
KENTUCKY	2	183,677
LOUISIANA	1	97,628
MARYLAND	5	1,602,988
MASSACHUSETTS	4	1,012,481
MICHIGAN	5	1,161,530
MINNESOTA	3	643,243
MISSISSIPPI	6	526,441
MISSOURI	5	845,599
MONTANA	1	350,710
NEBRASKA	3	487,554
NEW HAMPSHIRE	3	271,792
NEW JERSEY	1	860,273
NEW MEXICO	3	425,449
NEW YORK	15	1,693,474
NORTH CAROLINA	8	1,054,363
OHIO	10	1,080,300
OKLAHOMA	3	494,339
OREGON	2	651,159
PENNSYLVANIA	10	1,602,853
PUERTO RICO	1	137,743
SOUTH CAROLINA	2	933,640
SOUTH DAKOTA	1	56,859
TENNESSEE	4	702,064
TEXAS	11	1,681,350
UTAH	4	897,089
VIRGINIA	2	292,285
WASHINGTON	5	468,962
WISCONSIN	5	2,185,290

Question: The Materials Development and Informal Science Education Subactivity of the Science and Engineering Education Directorate appears to be slightly less for FY 1988 than FY 1987 in spite of the 16 percent increase for the total Directorate. Why?

What other Subactivities in the Directorate address grades K-12 and what percentage of the Directorate's funds are allocated for these educational levels?

Answer: Except for an accounting adjustment ($25,000) the $26 million for Materials Development and Informal Science Subactivity in FY 1988 is the same as in FY 1987. Activities for research in teaching and learning, formerly included in this subactivity, will be in the Research, Studies and Program Assessment Subactivity in FY 1988.

The Teacher Preparation and Enhancement subactivity includes $30.5 million for precollege activities, and the Research, Studies and Program Assessment Subactivity ($7.5 million) is directed primarily at the precollege level. The Research Career Development Subactivity includes $3.7 million for a Young Scholars activity for junior and senior high school students. The total of SEE funds being devoted to precollege education in FY 1988 is $67.7 million, almost 60% of the SEE budget request.

Question: Last year Congress increased the FY 1987 budget request for the College Science Instrumentation Program (CSIP) from $7.5 million to $9.5 million. Why does NSF propose to level fund this program again in FY 1988? Why was CSIP not extended to two-year and community colleges as directed by the Science, Space, and Technology Committee last year?

Answer: In FY 1988 the Foundation proposes several activities at the undergraduate level, for a total of $68 million. The $9.5 million for the College Science Instrumentation Program is just one component. Current planning estimates for FY 1988 include $22 million for instrumentation and laboratory development, through CSIP and undergraduate activities in other Foundation directorates. The budget plan submitted will bring balance to undergraduate support, and will permit us to pursue several recommendations of the National Science Board report on undergraduate science, mathematics and engineering education.

CSIP experienced very low success rates in its first years of operation, due to high proposal pressure. It was decided that it would be better for CSIP to support presently eligible institutions more adequately, rather than to face the virtual certainty that we would inadequately support both those institutions and the two-year colleges if eligibility were extended.

Question: How does the proposed FY 1988 graduate fellowship stipend, after taxes, compare to the FY 1987 stipend and to similar stipends provided by other agencies such as DOD and NIH?

Answer: The proposed annual NSF FY 1988 graduate fellowship stipend is $12,300, which is estimated to provide approximately the same after-tax stipend as the FY 1987 stipend level of $11,100. The other major federal graduate student fellowship programs are those of the Office of Naval Research (DOD) and of NIH. ONR will provide a stipend from $13,260 to $15,300 in FY 1988. The NIH stipend for FY 1987 was $6,552, with the FY 1988 stipend not announced as yet.

Question: Several years ago Congress directed NSF to contract for a study to provide assistance in developing a management and program assessment plan for NSF Science and Engineering Education Programs.

What is the status of this study?

Answer: We recently received from the Research Triangle Institute (RTI) their final report entitled, "Developing Options for Managing NSF's Middle School Science Education Programs." It currently is under NSF review. The other part of our response to Public Law 98-371 is a contract with SRI International to carry out an "Assessment of Initiatives Available to NSF to Address Problems and Opportunities in Science Education". That study, which is wider in scope and larger than the RTI effort, is now in its final phase. The final report is due in December 1987.

Question: What data bases and advisory groups did you use to determine the priorities and directions of the Science and Engineering Education Strategic Plan for FY 1987-1991? What role did the Science and Engineering Education Directorate's Advisory Committee - and the National Science Board's Task Committee on Undergraduate Education play in the development of the plan?

Answer: The strategic plan for science, mathematics and engineering education is grounded in data and assessments on the status of education, student demographics and achievement, teacher and faculty preparation, and the pipeline for training scientists and engineers.

Education and the development of human resources for science and engineering is a concern in all of the Foundation's programmatic directorates. The Science and Engineering Education Directorate (SEE) Advisory Committee discussed strategic plans and planning issues in SEE at meetings in June 1986 and November 1987. Additional perspectives for Foundation-wide participation at the undergraduate level were provided by special discipline-oriented workshops in mathematics, engineering and the sciences, and by internal NSF working groups.

The report of the National Science Board's Task Committee on Undergraduate Education provided a framework for the development of plans at the undergraduate level. The emphasis on leadership and leveraged program support, and the areas of focus (laboratory development and instrumentation; student research participation; faculty enhancement; and selected curriculum development), derive directly from the report.

Question: The Science and Engineering Education Strategic Plan has been criticized by science educators because it lacks specific objectives and related targets, resources and time-frames. Do you feel the Plan is adequate to develop and evaluate the contribution of NSF in science education in the next five years? What role did OMB have in shaping the content and specifics of the Plan?

Answer: The plan defines the Foundation's role in science and engineering education. Goals and strategies are clearly stated at each level of education. Plans for evaluation of Foundation activities, and for studies and analyses of science, mathematics and engineering education, are described. We feel the plan provides firm structure and direction for the Foundation's activities in science and engineering education. OMB reviewed and approved the plan.

Question: How much of the research budget goes to support graduate students in the form of research assistantships, and of this amount, how much goes to support foreign nationals?

Answer: In FY 1986, $134.2 million or 11% of the research budget went for graduate student support associated with research grants. The Foundation does not request citizenship data for graduate students as part of a research proposal. It has recently begun to collect these data as part of the final project report.

Of the total full-time science and engineering graduate students in doctorate-granting institutions in 1985, 26.5% were foreign citizens. The percentage of foreign graduate students varies widely with discipline and institutional mix. The profile of NSF supported graduate student research assistants does not appear to mirror the national profile. We believe that NSF's particular disciplinary and institutional support pattern results in a lower fraction of foreign graduate students supported than that of the total full-time science and engineering students.

Question: What is NSF doing to recapture students at the junior high and senior high levels into mathematics and science?

Is this the point at which students make decisions and form perceptions about math and science?

Answer: In FY 1988 NSF is planning a Young Scholars Program, a series of summer and school-year enrichment projects for high ability and high potential junior and senior high school students. One of the major objectives of this program is to enhance the students' interest in science, mathematics or engineering as possible career choices.

While students make decisions and form perceptions about mathematics and science at all ages, we believe that the junior and senior high school levels are the critical years for most of them. It is in the junior high school years that most students have to make a decision whether to begin an acceptable "science" track (e.g.--one that includes 4 years of high school mathematics), and an uninformed decision can preclude certain career options. It is in the senior high school years, of course, where college selection decisions are made.

Question: NSF's five-year plan for education talks about promoting partnerships between businesses, universities and school districts. Can you be more specific on how these partnerships would work and how NSF would promote them?

Answer: In our plans, we expect school district-business-university partnerships to work toward better science and mathematics education by identifying needs or problem areas and developing reproducible strategies to deal with those needs. Members would contribute resources (money, people, equipment, etc.) and share responsibility for projects they undertake. Grants would be made by NSF in support of these partnerships. A special solicitation, "Private Sector Partnerships to Improve K-12 Science and Mathematics Education" (NSF 87-11) was recently issued to invite proposals.

Question: In deciding which undergraduate programs to enhance in FY 1988, why did you disregard the priorities laid out in the Neal Report?

Answer: The Foundation's FY 1988 budget is a strong response to the Neal Report. Existing areas of undergraduate support are increased, and several new emphases are initiated. In FY 1988, activities are proposed for instrumentation and laboratory development, student research participation, faculty enhancement, curriculum development, and minority institutions. These activities reflect critical areas of need identified by the Neal report. Additional opportunities are provided through the Research in Undergraduate Institutions program for undergraduate faculty research which has specific impact on undergraduate education and training. In all, the Foundation's budget request includes $68 million for undergraduate activities, a $38 million increase over FY 1987.

TECHNOLOGY TRANSFER

Question: We understand the National Security Council (NSC) has delayed several of NSF's international initiatives.

What were the technology transfer concerns raised by the NSC regarding the participation of the U.S.S.R. participation and what is the National Security Advisor's position?

Has the President's Science Advisor been involved in the policy decision regarding U.S.S.R. participation and what is his position?

What impact has the delay had on U.S. relationships with the other international participants in the Ocean Drilling Program?

Answer: At this time it would be inappropriate for us to comment on an ongoing decision process. We would be happy to respond once the decision has been made on U. S. S. R. participation.

Question: In FY 1986, NSF was directed by the House and Senate Appropriations Committees to "continue to pursue appropriate programmatic support for IIASA (International Institute of Applied Systems Analysis)," at approximately $1.5 million. Why was the IIASA proposal not funded in FY 1986?

What role did the NSC play in the delay of funds to IIASA and what were their technology transfer concerns?

What is the current status of FY 1987 funding for IIASA?

Answer: The Administration believes that it is not wise to fund projects at IIASA at the present time. We believe that our security interests could be better served through bilateral programs, where we have more direct control over Soviet and Eastern bloc access to scientific equipment and Western data bases. Moreover, we believe that our bilateral political relationships are better served through direct, rather than multilateral, scientific cooperation.

We will be examining the possibility of redirecting the 1986 funding of $500,000 to bilateral programs with the Soviet Union and the Eastern bloc.

This decision was arrived at after very careful research and review within the Administration. It applies only to the funds identified in the FY 1986 budget. We are prepared to revisit this issue in connection with the FY 1987 budget if new circumstances warrant such a review.

Question: Many states now have programs to help businesses, particularly smaller ones, take advantage of the university research going on in their states. Is NSF involved in any of these programs? Does NSF do anything to encourage technology transfer?

Answer: The NSF Small Business Innovation Research (SBIR) program is designed to draw upon the special expertise of small business firms by supporting high quality research proposals on important scientific or engineering problems.

The SBIR solicitation for proposals specifically states that university collaboration with small business firms is encouraged, and one-half of SBIR awards have included university participation in the project. In addition, NSF sponsors Federal High Tech conferences which include seminars on state programs which highlight university/small business collaboration, and which include sessions on tech transfer from university research.

INTERNATIONAL SCIENCE

Question: The National Science Board's Committee on International Science and NSF's Task Force on International Strategy and Programs developed recommendations for NSF's role and responsibilities in international science. In response to these recommendations, NSF designated its Deputy Director as Acting Chief International Affairs Officer and created a Steering Group on International Science and Engineering to review NSF's activities and to develop strategies for enhancing NSF's effectiveness in this area.

Has the Steering Group produced a strategic and organizational plan for NSF's role in international science? If not, when will it be ready for publication?

Answer: The Steering Group on International Science and Engineering, chaired by the Deputy Director, completed its review of NSF's international activities in May 1986 and forwarded its recommendations to the Director and his Executive Council. These recommendations dealt with a number of strategic and organizational issues, including: NSF's relations with other agencies in the international area, including OSTP and the State Department; its international information gathering, analysis, and dissemination activities; the functions of its Division of International Programs (INT); and NSF's relationships with both governmental and non-governmental multilateral organizations. The National Science Board's policy that international activities should be considered integral to all NSF activities provided the general policy framework for the Steering Group's considerations. Its recommendations have been incorporated where appropriate into the Foundation's ongoing and planned programs.

Question: Can you describe specific new initiatives that NSF has begun or will soon begin as a result of these studies and assessments of NSF's responsibilities in international science?

Answer: NSF has moved to strengthen its liaison with other agencies, principally through the Working Group on International Infrastructure, Education, and Facilities of the FCCSET Committee on International Science, Engineering, and Technology (CISET). We have established an Information and Analysis Section within the

Division of International Programs. The new (since January) Director of the International Division, has taken steps, consistent with the recommendations of the Steering Group, to improve the effectiveness of the division's service functions to NSF's research directorates and its management of both bilateral and multilateral support programs. The Foundation has taken an active role in a number of key bilateral agreements, including the U.S.-Japan Agreement on Cooperation in Research and Development in Science and Technology, the U.S.-India Science and Technology Initiative, and the new initiative with Brazil.

SOCIAL AND BEHAVIORAL SCIENCES

Question: Funding for research in the Social and Behavioral Sciences suffered disproportionate budget reductions from FY 1981 to FY 1986.

Has the National Science Foundation restored funding for research in the Social and Behavioral Sciences in current dollars to their levels before FY 1980? Should the funding level not be well beyond the FY 1980 level in FY 1988? If the NSF budget doubles in the next five years, what priority will be given to the behavioral and social sciences?

Answer: With the FY 87 current plan, funding (in current dollars) for the Social and Behavioral Sciences has been restored to the pre-FY 80 levels of support, specifically +27% in current dollars since FY 79.

In FY 88, BBS is requesting an increase of +13.3% for the Social and Economic Science Subactivity and +12.2% for the Behavioral Science component of the Behavioral and Neural Sciences Subactivity, totalling +12.7% combined. Since FY 1983, the directorate has made significant progress in restoring funding to FY 1980 levels. Specifically with this FY 88 request, the Social and Behavioral Sciences have increased +67% since FY 83 (the beginning of the restoration); this is compared to all of BBS which has increased +55% since FY 83. BBS has attempted to balance the increases requested for the Social Sciences in the FY 1988 budget against other significant scientific priorities, such as the recent research emphases in biotechnology and global geosciences, as well as pressing infrastructure problems such as the need for instrumentation, and support for scientific personnel, including undergraduate students.

The Foundation is in the process of formulating a five-year budget plan and anticipates presenting a plan for doubling its budget to Congress in FY 1989. As reflected in the budget increases for the Social and Behavioral Sciences over the last four years, we anticipate that these areas of research will remain a priority within the Foundation. The National Academy of Sciences is in the process of completing a report on research priorities for the next decade within the Social and Behavioral

Sciences. We are anticipating that its release will assist us in formulating the five year plan.

Question: What is the status of support for national databases?

Answer: The primary national databases include the National Election Study, the Panel Study on Income Dynamics and the General Social Survey; other smaller databases exist and are supported by NSF as well. In FY 1985 and 1986, $5.9 and $7.9 million were spent respectively, supporting all of these. In FY 1987 and 1988, planned expenditures will be $9.2 and $11.3 million, and include support for the National Center for Geographic Information.

Question: Can you tell us where in the BBS Directorate they are supported and at what level?

Answer: The databases discussed above are supported through the Social and Economic Science Subactivity.

U. S. ANTARCTIC PROGRAM

Question: The Committee understands that the Foundation has completed a feasibility study on the recovery of a LC-130 aircraft that crashed in Antarctica in 1971 and has subsequently been buried in ice and snow.

a. What conclusions have you reached concerning recovery of this aircraft and how do you propose to proceed?

b. If the aircraft can be returned to service, what impact would it have on the overall logistical portion of the program?

c. How would addition of the aircraft to the fleet impact the costs associated with fleet maintenance?

d. Who currently holds title to the aircraft? What plans have been made to transfer the title to the Foundation?

e. Will legislation be necessary to transfer the title of the aircraft to the Foundation?

Answer: The aircraft has been dug out and examined. Lockheed and Navy engineers have determined that the aircraft can be recovered. It should be possible to repair it and fly it out next season, probably in January 1988.

Its addition to the LC-130 fleet can, we think, extend the total life of the fleet. Because the airframe has far fewer flight hours, it will be substituted in the ongoing extensive rework program for one of the oldest aircraft. No significant addition of fleet flight hours is planned; thus additional maintenance costs resulting from the recovery are expected to be fairly low--under $1 million per year.

Title is vested in the Department of Defense, and will be transferred to NSF via interagency agreement. Legislation is required (31 USC 1343).

Question: The Committee understands the U.S. Coast Guard icebreaker, Glacier, can no longer be used for operational support due to hull deterioration. In addition, Glacier has some drawbacks as a research vessel. The Polar Duke, on the other hand, is an ice strengthened research platform, but is not equipped to break ice like Glacier.

a. What plans have you made in the wake of the retirement of Glacier?

b. What is NSF's planned contribution to the purchase of an icebreaker by the Coast Guard?

Answer: The lease by NSF of an icebreaking research ship proposed in the FY 1988 budget should provide a superior substitute for Glacier. While not a heavy icebreaker, the ship will have greater research capability and will provide an opportunity to extend the length of the research season in Antarctica. It also can be obtained and operated at a small fraction of the cost to the Government of a military (Coast Guard) icebreaker.

NSF financial support to Coast Guard icebreakers is limited to reimbursement of costs stemming directly from USAP operational support requirements. These consist primarily of ice channel breaking and maintenance.

Question: What is the status of the New Zealand government's policy with respect to visits by nuclear powered vessels?

Answer: The government of New Zealand policy has been, and continues to be, to prohibit nuclear powered vessels from entering its territorial waters and ports.

Question: Last year legislation was apparently pending that if enacted could have far reaching impacts on the operation of the U.S. Antarctic Program. Would you update the Committee on this matter and comment on the impact of New Zealand's governments position?

Answer: We understand that legislation prohibiting entry of nuclear powered ships or ships and planes with nuclear weapons may be enacted by the New Zealand Parliament during May-June 1987. The U.S. policy is to neither confirm nor deny whether U.S. ships or aircraft are nuclear armed. However, under the terms of the Antarctic Treaty, all countries, including the U.S., are required to announce the contents of ships and planes to Antarctica in advance including specifically military equipment. Thus, enactment by New Zealand of the proposed legislation may not impact the U.S. Antarctic Program.

APPENDIX 5

Additional Statements for the Record

UNIVERSITY OF SOUTHERN CALIFORNIA
UNIVERSITY PARK
LOS ANGELES, CALIFORNIA 90089-0371

DEPARTMENT OF BIOLOGICAL SCIENCES

February 18, 1987

Mr. Robert O'Neill
House Science and Technology Committee
Room 2319 Rayburn Building
Washington, DC 20515

Dear Mr. O'Neill:

As I mentioned to you in our recent telephone conversation I would very much like to testify in person before the House Committee considering the NSF budget. In particular I wish to give testimony to the NSF Subcommittee on the need for a Polar Research Vessel (PRV) which appears as a $13 M line item in the Division of Polar Programs (NSF) budget for 1988. The primary reason for this request is that our current fleet of aging vessels which operate in ice covered regions is woefully inadequate to support the research needs of the U.S. scientific program.

I actively participate in the U.S. polar research effort and have made or led nine expeditions to Antarctica and three to the Alaskan Arctic during the past decade. As a member of the National Academy of Sciences, Polar Research Board, I have served during the past two years as Chairman of the Ad Hoc Committee to Evaluate Polar Research Platforms (Ships). During the course of these activities I have formed strong personal opinions of the U.S. capability to conduct first-rate oceanographic research in the polar regions. Through first-hand collaborative research with many U.S. and foreign scientists as well as through surveys of the U.S. polar research community, I have gained a broad perspective of the science community's view on these matters. I would appreciate the opportunity to present these views before the NSF Subcommittee of the House of Representatives.

I present for your information a brief outline of the issues which I would like to address.

To: Mr. Robert O'Neill
From: Cornelius W. Sullivan
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With the exception of R/V POLAR DUKE, an NSF leased ship, the U.S. nominally has only 4 vessels which have the ability to operate in the ice-covered portions of the arctic and antarctic regions of the world ocean. All four of the vessels are owned and operated by the U.S. Coast Guard and yet the primary mission of the USCG does not include science. Nevertheless, the USCG has provided ship support for scientific research for the past few decades. However, during the past two years two of these four vessels (WESTWIND and GLACIER) ceased to remain operative as icebreakers because of structural inadequacy and ice damage. At the time of writing this letter, one of the two remaining icebreakers, POLAR STAR requires extensive yard work and is not available for scientific research. As a result of these events the U.S. capability of supporting research in ice covered oceans is cut to one fourth! The outlook for improvement of this situation is not bright unless action is taken to acquire one or more dedicated polar research vessels with ice breaking capabilities now.

One might ask why do we need scientific research vessels capable of operating in ice covered oceans? I would respond that there are three reasons based on rational thought and one on national pride. First of all, The U.S. needs polar research vessels to remain in the forefront of the business of acquiring new knowledge in polar regions, ie. the basic research need in biology, chemistry, earth and atmospheric sciences. For instance, the Polar Research Board, in its report, Research Emphases for the U.S. Antarctic Program, identified as its top priority, a multidisciplinary research program at the ice edge which requires an icebreaker.

Approximately 10 percent of the world oceans are seasonally covered by 3 to 10 feet of sea ice and what happens under this ice cover is of considerable importance to our national interests.

Second, U.S. economic interests are well served by our knowledge of polar biology and earth sciences, especially with regard to developing a rational plan for management of the living and mineral resources of the region. Living resources include prominent fisheries for krill in the Southern Ocean and for pollock, tannercrab and king crab in the Alaskan Arctic. Mineral resources in the arctic are dominated by petroleum and in the antarctic by mostly unproven resources which may represent a great resource potential for the next century.

Antarctic issues require that the best scientific information be available so that our delegates make wise decisions with regard to international efforts to manage living resources primarily through the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and non-living resources through the proposed minerals regime of the Antarctic Treaty System.

To: Mr. Robert O'Neill
From: Cornelius W. Sullivan
Page 3.

Thirdly, the defense of our nation is inherently tied to knowledge of the polar oceans. The Arctic is the nation's only common border with the Soviets. Both American and Soviet submarines gain tactical and strategic advantage by operating under ice covered seas. Thus, defensive and offensive strategies of the Superpowers require extensive knowledge of the physical, chemical and biological characteristics of the arctic seas, especially, as they influence optical, acoustic and thermal features of these waters.

While these three broad areas of need provide an abundant rationale for acquisition of research platforms, I am also influenced by an emotional issue, one of national pride. A growing number of foreign nations are mounting increasingly impressive research programs in both the arctic and antarctic regions. U.S. scientists have already begun to rely on Soviet, Norwegian and West German research vessels to support their research programs. The Soviets have many more ships and more advanced technologies for operation in polar seas that does the U.S. The West German R/V POLARSTERN is undoubtedly the finest polar research vessel afloat and as a result of her activities, bright young German scientists are running away with the major new discoveries in polar research. It is difficult for me to watch the American polar science effort rapidly slipping to second place not for lack of creative genius, but for lack of suitable platforms from which U.S. scientists can probe the least understood regions of the world oceans.

Thank you very much in advance for the opportunity to present my opinions on these important matters. I remain,

Sincerely yours,

Cornelius W. Sullivan

Cornelius W. Sullivan
Professor, Director,
Marine Biology Research Section
(213) 743-6904

CWS:lvh
(#115.4)

ACCT
Joint Commission
On Federal Relations
AACJC

March 6, 1987

The Honorable Doug Walgren
U.S. House of Representatives
2241 Rayburn House Office Building
Washington, D.C. 20515

Dear Doug,

During our recent visit, you said you would gladly incorporate in the hearing record of your Subcommittee a statement from us on the NSF reauthorization. That statement is attached.

You also held open the possibility that the full Committee would conduct hearings later this month. If it were possible for one of our Joint Commission members to give this testimony in person during such hearings, we would prefer to do that. If you could put us on that schedule, if it develops, we would appreciate it very much.

Thank you again for your interest and leadership.

Sincerely,

Frank

Frank Mensel
Vice President for Federal Relations, AACJC
Director of Federal Relations, ACCT

FM:egd

Enclosure

cc: Edward Liston
Dale Parnell
William Meardy

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Statement on

FY'88 National Science Foundation Reauthorization

for the

Joint Commission on Federal Relations
of the
American Association of Community and Junior Colleges
and the
Association of Community College Trustees

by

Sandra L. Ritter
Joint Commission Chair
and
Chair of the Board of Trustees
Oakland Community College
Bloomfield Hills, Michigan

Subcommittee on Science, Research and Technology
Committee on Science and Technology
U.S. House of Representatives
February 19, 1987

Mr. Chairman, we thank you for this opportunity to express the concern of the Nation's community colleges over the National Science Foundation's role in undergraduate science and engineering education. In a word, our concern is competitiveness.

The American economy is facing a long, uphill struggle to meet global competition, a struggle in which undergraduate education in science and math will assuredly play a pivotal role, yet a struggle in which national success is far from certain.

It is a struggle, we believe, that calls into question the meagre contribution that NSF currently makes to undergraduate education. What, in fact, should be the responsibility of the NSF for undergraduate education? Only Congress in general, and this Committee in particular, can answer that question. We think there is no committee more suited to help shape U.S. policy for competitiveness than the Committee on Science and Technology.

It seems to us that Congress defined NSF's role when the Foundation was established. One would assume from the mission statement in the original law that the NSF would play a broad and dynamic role in strengthening postsecondary education in math and science.

But that has not been the case. Over the years the work of the NSF has become increasingly focused -- almost entirely focused -- on postgraduate study, on turning out more and more scientists and engineers with advanced degrees. The Foundation has ignored the institutions producing the technicians who support the professionals. Moreover, the Foundation barely recognizes the colleges that prepare young men and women for success in advanced studies.

Our country can be proud that the network of great research universities is serving in such large measure, particularly in science and engineering, as "graduate school to the world." But that hardly justifies the very narrow approach to national need that the NSF is pursuing. In short, Mr. Chairman, NSF should not be contributing directly and indirectly to doctoral programs for students from other lands, at the expense of meeting our own economy's pressing demand for the technical education it must have to meet global competition.

For at least the remainder of this century, the ability of our country to meet the global challenge will rest as strongly, if not more strongly, on the quality of its technicians as on the prowess of its postgraduate scientists and engineers.

Among the reasons that our economy has been losing ground to global industry, none is more pivotal than technical education. In terms of across-the-board depth and competence, the American skill base is being outdistanced by more advanced competitors. Our technical education is not keeping pace. If American employers, particularly private industry, are going to regain the ground we've been losing in recent years, they are going to have to have the most skilled workforce in the world.

The struggle we face in overtaking the competition, as graphically illustrated by the lead in electronics and robotics commanded by Asian countries, is not complicated by technology alone. The largest complication may lie in the rapidly changing demographics of our own populations.

Our fastest growing populations are the ethnic minorities, often concentrated in urban centers, where high school dropout rates are running as high as 50 percent. And the fastest growing workforce component is women, who do not pursue technical disciplines and who are not encouraged to do so. What these developments mean is that we have a smaller pool of capable people to work with and that to be most effective we must broaden our stress on education levels - prime the pump so to speak - and take full advantage of every opportunity to generate technical skills in our own people.

To rebuild the American workforce as the most skilled workforce in the world is a challenge that will demand a well conceived and well focused national strategy. Our federal system presently has no designated "competitiveness" agency, and this may be the root of the problem. Competitiveness initiatives are presently scattered among scores of agencies, and such fragmentation is making the challenge much more difficult.

With a broader focus and more balanced program, and with the resources necessary to lead effectively a revitalization of secondary and postsecondary math and science education, the NSF might qualify as that agency. But the national interest has not been well served by the NSF's neglect of undergraduate education, accentuated in its total disregard for lower-division science and math.

If our views seem blunt, Mr. Chairman, we mean only to convey our sense of the urgency of the global challenge that faces our economy and our way of life. Clearly, the standard of living that Americans have come to cherish in the last two generations hangs in the balance.

We think our words are no more blunt than those of the report just published by the American Chemical Society, entitled "Critical Issues in Two-Year College Chemistry," which grew out of the 1985 Invitational Education Conference sponsored by the Society's Committee on Education. Especially pertinent are the Conference's recommendations to the National Science Board, which we hope your Committee, Mr. Chairman, will find equally pertinent to your efforts to help the Congress establish a winning competitiveness policy. We ask your permission to include this part of the Report in the hearing record.

You may already be familiar with the Pimentel and Pister resolutions adopted last November by the National Science Board, but in case you are not, we share them now and ask that they also be incorporated in the hearing record.

We also would like to include in the record, Mr. Chairman, our Joint Commission's summary of the steps we suggest to Congress on competitiveness, along with the column by Frank Mensel entitled, "Community Colleges and the National Science Foundation," that appeared in the latest issue of the ACCT Advisor, published by the Association of Community College Trustees.

In closing, Mr. Chairman, we emphasize that the community, technical and junior colleges are committed to helping make the American workforce the most skilled in the world. Our colleges are intensifying their efforts across the land to work with local employers and industry to achieve this goal. We also believe this should be the NSF's highest purpose and goal. The nation and the Congress cannot afford to overlook the fact that, in a world where progress is increasingly dependent on technological success, the quality of technical education becomes wholly dependent on the quality of undergraduate lower-division math and science education. This linkage grows stronger year by year, and we count on your leadership, Mr. Chairman, to make it a part of NSF policy and national competitiveness strategy. Thank you again for the opportunity to share our concern.

CRITICAL ISSUES IN TWO-YEAR COLLEGE CHEMISTRY

REPORT WITH RECOMMENDATIONS

Report of the 1985 Invitational Education Conference
Sponsored by the Society Committee on Education
of the American Chemical Society
Chevy Chase, Maryland
November 15–17, 1985

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The Two-Year College Chemistry Conference of the Division of Chemical Education, Inc. *generously provided partial financial support for the Conference and the distribution of this report.*

COVER – NORTHERN VIRGINIA COMMUNITY COLLEGE – ALEXANDRIA CAMPUS. J. PICKERELL

To the National Science Board

Two-year colleges constitute a significant segment of, and make a major contribution to, undergraduate science and engineering education in the United States. The magnitude of this contribution is reflected in the fact that two-year colleges presently enroll 41% of all undergraduate *credit* students, 55% of all first-time college freshmen, and more than 50% of all minority students.

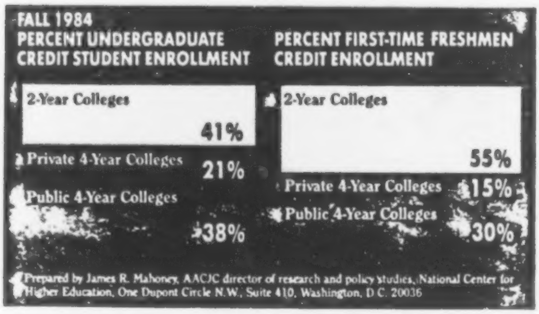
Modern, comprehensive community colleges, regardless of their varied histories and public images, are today providing the first two years of postsecondary education for substantial numbers of students who eventually receive a baccalaureate degree. These graduates are the nation's next generation of scientists, engineers, and teachers. It cannot be in the country's best interest to neglect the all-important first years of their college education.

Three very serious problems undermine the ability of two-year college chemistry departments to fulfill their role as providers of high-quality science education for both transfer and technical students. These colleges:

1. **Are frequently staffed with overworked faculty who have few resources for professional growth.**
2. **Are chronically plagued by inadequate laboratory and instructional equipment.**
3. **Are forced to accommodate large numbers of underprepared students.**

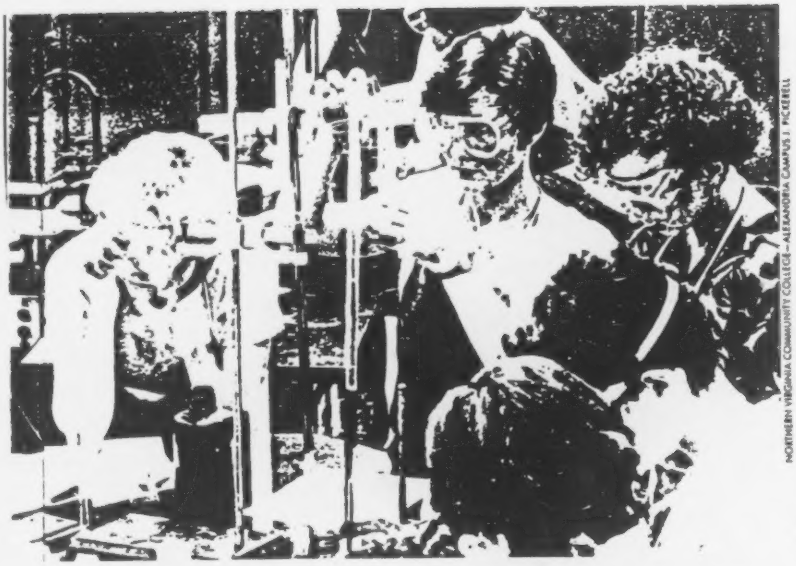
These problems are of such magnitude that only the federal government, acting through the National Science Foundation in its role as the leader in science research and education, can affect the needed changes.

We call upon the National Science Board to recognize (a) the indispensable contribution that contemporary two-year colleges already make to undergraduate science and engineering education, and (b) their potential for greatly increasing that contribution provided they receive the guidance and support of the federal government at a level consistent with their current and potential role in educating America's next generation of scientists.



Prepared by James R. Mahoney, AACJC director of research and policy studies, National Center for Higher Education, One Dupont Circle N.W., Suite 410, Washington, D.C. 20036

Community, technical, and junior colleges continue to provide the majority of American college students with their first experience in higher education. Two-year colleges enroll the largest share of undergraduates compared with private and public four-year colleges.



NORTHERN VIRGINIA COMMUNITY COLLEGE—ALEXANDRIA CAMPUS J. PICKERELL

Community colleges are the first and best opportunity in postsecondary education for many students.

Faculty Growth and Development

We recommend that the National Science Foundation increase its level of activity in providing faculty development opportunities to college science teachers at minimum personal expense. Specifically, the NSF should

- support an expansion of the existing Institute for Chemical Education (ICE) that will enable ICE to provide in-service development for two-year college chemistry teachers;
- re-establish faculty development opportunities for college science teachers such as the College Science Improvement Program (COSIP), Chautauqua courses, and other programs for growth and renewal that are scheduled during times when faculty can participate; and
- establish programs to provide additional in-service education, via modern instructional delivery methods, to two-year college chemistry teachers who are unable to attend conferences and workshops.

Laboratory and Instructional Equipment

We recommend that the National Science Foundation increase its level of activity in supporting the acquisition of modern instrumentation in the two-year colleges. Specifically, the NSF should

- modify the Undergraduate Research Participation Program to encourage research by students (directed by two-year college faculty) in the two-year colleges,
- modify the College Science Instrumentation Program so that two-year colleges become eligible for funds,
- provide support for a number of regionally located and well-equipped, model science laboratories in two-year colleges,
- make umbrella grants to professional associations (or state two-year college agencies) which would then make smaller disbursements to individual colleges submitting proposals for the purchase of instruments costing under $3,000, and
- establish a program to support cooperative instrument repair services that could be used by a number of institutions in a geographic area.

Curriculum Improvement

We recommend that the National Science Foundation continue its support of exisiting programs in the new instructional technologies, such as Project Seraphim, and expand these efforts to specifically include material for use in two-year colleges. The Foundation should also establish new programs to take full advantage of modern electro-optical technologies, such as compact disks, teleconferencing, and videodisks, that would enable two-year colleges to bring enhanced learning opportunities to their students.

American Society for
Engineering Education
suite 200
eleven dupont circle, washington, d.c. 20036 **(202) 293-7080**

March 19, 1987

The Honorable Doug Walgren
Chairman
Science, Research, and Technology Subcommittee
2318 Rayburn Building
Washington, D.C. 20515

Dear Mr. Chairman:

On behalf of the American Society for Engineering Education, I respectfully urge the Subcommittee to provide an FY 1988 authorization for the National Science Foundation of at least the Foundation's request. While we understand the difficult budget and programmatic choices facing the Congress this year, we believe NSF's role in fostering the nation's economic well-being and national security is so vital, it warrants priority support.

The American Society for Engineering Education (ASEE) is a membership organization of more than 10,000 engineering faculty and students as well as university and industry representatives.

The National Science Foundation is the primary federal agency charged with supporting fundamental research in engineering and science. Through its varied research programs, NSF helps provide the scientific and engineering base that will support the nation's technological development for decades to come. Through such innovative programs as the Engineering Research Centers, it brings together academia and industry to address pressing technical questions in such areas as composites, manufacturing, computers, robotics and biotechnology, all vital elements which contribute to economic competitiveness.

Through NSF's education programs, including fellowships and grants, the Foundation helps universities educate the engineering and scientific talent necessary for our increasingly technological society.

Of special importance in this year's proposed budget is a new undergraduate education initiative undertaken in response to the recent National Science Board report (NSB 86-100) which identified an urgent need for NSF action.

Under this initiative, NSF funding will leverage support from academia, industry and state and local government in an effort to significantly improve undergraduate education in science, mathematics and engineering. The Foundation will provide much-needed federal leadership in such areas as revitalizing outdated curricula, encouraging faculty to update their skills and offering research opportunities for promising undergraduates.

Because the baccalaureate degree is the highest formal degree obtained by two-thirds of the nation's engineers, this NSF initiative will have a major positive impact on the capability of the nation's engineering workforce. For that reason, if there is opportunity for the Subcommittee to raise the overall NSF authorization above the requested level, we believe the undergraduate initiative is an area to which an increase would be appropriately directed.

In light of the Foundation's vital dual mission in research and education, we respectfully urge you to provide NSF with at least the full $1.89 billion requested. This increase will enable the Foundation to enhance its ongoing programs and undertake several important new initiatives, as well as take a major step toward the most desirable goal of doubling the Foundation's budget within five years.

Thank you for your consideration of our views. If we can provide you with additional assistance or information, please call on us.

Sincerely,

F. Karl Willenbrock

F. Karl Willenbrock
Executive Director

NATIONAL SCIENCE FOUNDATION

news

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FOR RELEASE:
IMMEDIATE
NSF PR 86-29

NSB CITES SERIOUS FLAWS IN UNDERGRADUATE SCIENCE, MATH AND ENGINEERING EDUCATION

Undergraduate education in science, mathematics and engineering contains "serious deficiencies" that are harming this country's economy and security, according to a National Science Board (NSB) report made public today. The NSB is the National Science Foundation's (NSF) policymaking body.

The report cited three areas that require immediate attention "of the highest priority" by the NSF and other Federal agencies, by the states and by the private sector.

The areas of gravest concern, according to the report, are laboratory instruction, faculty preparation and courses and curricula.

The report was prepared by the NSB's Committee on Undergraduate Science and Engineering Education, chaired by Dr. Homer A. Neal, provost at the State University of New York at Stony Brook. The Committee held four public hearings at which industry, government and academic leaders presented their views on undergraduate education.

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"The findings and recommendations in this report should help the National Science Foundation develop innovative programs responsive to the serious problems identified by the Committee," Dr. Neal said. "I trust that our analysis of these issues will be helpful to other organizations and individuals concerned with these critically important matters--the health of undergraduate education in science, mathematics and engineering."

Dr. Roland W. Schmitt, Chairman of the NSB and Senior Vice President for Corporate Research and Development at the General Electric Company, commended the Committee for its thorough analysis of the problems facing undergraduate education.

"We cannot afford to allow the deterioration of our undergraduate science and engineering education system to go on unchecked." he said. He instructed the Foundation to begin immediately to devise a plan to respond to the problems outlined in the report.

The Committee recommended that the NSF's annual expenditures at the undergraduate level in science, mathematics and engineering education reach a "total of $100 million in new funds by FY 89" with appropriate distribution among the following areas of highest priority: laboratory development, instructional instrumentation and equipment, faculty professional enhancement, course and curriculum development, comprehensive improvement projects, undergraduate research participation, minority institutions program, and information for long-range planning.

The major objectives of the study were to assess the character and condition of undergraduate education in mathematics, engineering and the sciences and to determine what role the NSF should play to strengthen and improve it.

"The Committee has concluded that the Foundation's role must be strong leadership of a nation-wide effort, an effort that will require participation by public and private bodies at all levels," the report says.

One of the areas of greatest concern, laboratory instruction, has deteriorated to a point where it is often uninspired, tedious and dull and conducted with obsolete and inadequate instruments, the report states. It is being eliminated from many introductory courses and too little funding is available to support faculty who have creative ideas for laboratory redevelopment.

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Faculty members often are unable to update their disciplinary knowledge continuously or maintain their teaching skills, the report says. Many are unable to use computers and other advanced technologies. In some fields serious shortages of qualified faculty exist.

Courses and curricula are frequently out of date in content and are poorly organized for students with different interests. The same is true for instructional materials now in use, according to the report.

"These (key) deficiencies contribute to trends in student performance and behavior that are adverse to the national interest: fewer students are choosing careers in science and engineering; certain specialties are not attracting the number or quality of entrants they need; enrollment in teacher education curricula in mathematics and the sciences is critically low; and the supply of well-qualified teachers for the school is short," the report says.

"The size of the 18-19 year-old age group will decline substantially in the next decade. Unless education in mathematics, engineering and the sciences is made more effective for all students and more attractive to potential faculty members, and especially to the presently underrepresented (women, minorities, and the physically handicapped), both the quality and number of newly educated professionals in these important fields will fall well below the nation's needs--with predictable harm to its economy and security."

The report said responsibility for the academic health of undergraduate education lies primarily in the nation's colleges and universities and their governing bodies. Responsibility for the financial health of the educational institutions lies primarily with states, municipalities and the many supporters of private higher education.

"Most of the direct effort to reverse the downtrends of quality in undergraduate mathematics, engineering and science education must be made at the state and local levels of government and in the private sector," the report says. "Those are the places where educational policy is made and the basic financial support for higher education is marshalled."

-more-

The National Science Foundation, the report said, cannot assume responsibility for the financial health of higher education, even in the sciences and engineering. But that Federal agency can and should expand and establish programs which help restore academic health to undergraduate education in the fields for which it is responsible.

The NSB Committee concluded that the NSF should be "a significant presence" in undergraduate science, mathematics and engineering education. But, it said, the greatest efforts should come from the people directly responsible for the health of colleges and universities.

"The Federal government, in general, and the National Science Foundation, in particular, cannot and should not be looked to for the substantial continuing infusions of resources that are needed," the report said.

In addition to Dr. Neal, members of the Committee were Dr. Jay V. Beck, professor emeritus of microbiology, Brigham Young University; Dr. Rita R. Colwell, vice president for academic affairs and professor of microbiology, University of Maryland; Dr. Thomas B. Day, president of San Diego State University; Dr. James J. Duderstadt, dean, College of Engineering, University of Michigan; Dr. Norman C. Rasmussen, professor of nuclear engineering, Massachusetts Institute of Technology; Dr. James L. Powell, president, Franklin and Marshall College (Committee advisor), and Dr. Lester G. Paldy, dean of continuing education, State University of New York at Stony Brook (Committee consultant).

Single copies of the NSB Committee's report may be obtained from the Office of Legislative and Public Affairs, Room 527, National Science Foundation, 1800 G Street, N.W., Washington, D.C. 20550 or telephone (202) 357-9498.

-end-

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WASHINGTON, D C 20550

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NSF ENGINEERING RESEARCH CENTERS: LESSONS LEARNED

Cross-disciplinary research conducted at 11 ERCs, so far, is expected to eventually trigger the development of new technologies by industry.

Nam P. Suh

The National Science Foundation has high hopes for the Engineering Research Centers, or ERCs as we call them. They are breaking new ground in engineering, and they are going to help us in the long-term effort to improve our international competitiveness.

Even though the first ERC awards were made barely a year ago, we have learned a number of important things about them and about the U.S. engineering community that are critical in building engineering and technological strength in America:

1. Our engineering schools are anxious to do pioneering work in cross-disciplinary research, and they have a wealth of ideas for pushing engineering forward in the ERC structure. We received 244 proposals for ERCs from 114 engineering schools requesting $3.5 billion in support. What makes those numbers even more significant is that NSF had only $10 million the first year and $21.7 million in the second year to respond to that $3.5 billion in requested funds.

2. There is tremendous interest in industry for this type of industry/university interaction. Industrial firms are putting up money and other resources to become full-fledged partners in this venture. For every federal dollar put in, industry and state governments have put in $1.24.

3. Universities are coming through with the strong backing necessary for the Centers' success. So far, this crucial university support is evident at all 11 institutions where centers have been established. It is a little early to pass final judgment in this area, but we are encouraged by the experience so far.

4. We are convinced that for the U.S. engineering infrastructure to be strong, we must have a proper balance among cross-disciplinary research, single investigator initiated research, research in traditional engineering sciences and in emerging engineering fields. The cross-disciplinary research area is currently the weakest and requires strengthening. But, at the same time, we must make certain that support for individual research projects also remains strong.

5. The ERC program is a positive step forward in strengthening the international competitiveness of the U.S. But, it is only a start on what must ultimately be done to bring U.S. engineering to the level it should be if we are to continue as a world leader in technology. It will require a much larger investment in engineering research to create technological options needed to make sound socioeconomic/political decisions that can enhance our international competitiveness. A realistic estimate of the amount needed for NSF's engineering program to make a difference is about $500 million annually.

6. Other nations are envious of our ability to move forward with an ERC program in such a short time. While we often joke about Washington's red tape, the fact is, both the executive and legislative branches can, and often do, move quickly to establish a priority program. The gestation period for the ERCs was only about 19 months from idea to funding. The agility of our system and the willingness of Congress and the Office of Management and Budget to go for a new promising program, even under severely restrained budget conditions, gives us an edge over our counterparts overseas who must deal with much more cumbersome and bureaucratic systems.

A Trigger for New Technologies

We expect that the cross-disciplinary research conducted at the ERCs will trigger the development of new technologies by industry over the long term. We also expect the unique educational experience provided both graduate and undergraduate students at these centers will better prepare them to practice engineering upon graduation. Consequently, through research and education, we see the centers helping industry meet foreign competition. The problems of international competitiveness are complex and pervasive. I think it is quite obvious that these problems go far beyond research.

Studies show that the U.S. has benefited the most through technological innovation in the past. For this reason, we must continue to generate creative engineering graduates. Moreover, we have to seek our own solutions to enhancing our international competitiveness by making use of our own strengths and cultural heritage rather than trying to emulate others whose background and constraints are very different from ours.

Nam Suh is assistant director for engineering at the National Science Foundation. Prior to his appointment in 1984 he was professor of mechanical engineering at the Massachusetts Institute of Technology, and director of MIT's Laboratory for Manufacturing and Productivity. He received his Ph.D. in mechanical engineering from Carnegie-Mellon University. This article is adapted from his paper presented at a symposium, "The Engineering Research Centers: Leaders in Change," held at the National Academy of Sciences, Washington, D.C., June 30 and July 1, 1986.

During the past 40 years, our engineering schools have become very specialized in an effort to strengthen the engineering science base, which was an appropriate emphasis during that period. Consequently, the existing university culture tends to operate within the boundaries of well-established disciplines. That is a difficult environment for cross-disciplinary research. We need a new mechanism to make this happen; and the ERC's are proving to be a very popular instrument, judging from all who wish to have one.

The road ahead for the ERCs will not be an easy one. Each of the centers must mature in a system that has, for many years, recognized and rewarded individual instead of team efforts. The centers may also experience difficulties in maintaining the team spirit needed to foster cross-disciplinary research because, in most cases, they do not have a specific engineering product, such as a space shuttle, to produce.

It is important that each ERC develop a strategic plan, and that students as well as professors understand the strategic goals of the center and their role in achieving those goals. Obviously, these plans and the goals must be in harmony with the long-range goals of the universities where each ERC resides. They must have a contingency plan that will carry them beyond the five-year period of NSF funding. I want to stress that we plan to continue funding as long as they do a good job. But, the point is, if the universities believe that the ERCs are filling an important function, they are likely to continue the ERCs even if NSF is not able to continue support for them.

Obviously, for the ERCs to achieve their goals, they must work with industrial firms. We are gratified to see the spontaneous support and response of U.S. industry to the ERC initiative. The ERCs have done a good job of involving industry in their endeavor. (See article beginning next page.)

One of the most important criteria in selecting an ERC for support was the leadership—both intellectual as well as managerial—of the center director. We are very satisfied with the results. We also recognize that the ERCs themselves must be built into sufficiently strong entities to survive leadership changes that will come, just as they do in all organizations.

So, it is a combination of leadership and institutional strength, plus first-rate research, that will carry the ERCs forward. The first 11 ERC's have an excellent chance to make it in all three and to fully meet the announced goals of the ERC program.

I want to stress that the United States is in very serious competition for technological leadership. It is a long-distance race. We will not know the outcome for some years. To win requires a tremendous investment in research, particularly in engineering, and a coming together of our universities, industry, and federal agencies and government research laboratories. It may be the greatest challenge we have faced since World War II.

There can be no question that our competitors are determined to be first in engineering. They are devoting tremendous resources to that effort and they intend to win. We can meet the challenge and continue as the world leader in technology if all of us make the commitment to making our research in the engineering disciplines, in the ERCs, and in federal and industrial laboratories, second to none.

Supplemental Statement

by

Dr. Sheila E. Widnall

President

American Association for the Advancement of Science

on

The Fiscal Year 1988 National Science Foundation Budget Authorization Request

Submitted to

Subcommittee on Science, Research and Technology

Committee on Science, Space and Techology

U.S. House of Representatives

March 23, 1987

Introduction

We thank you for the opportunity to express some additional views on the Fiscal Year 1988 National Science Foundation Budget Authorization Request. Again, I would like to clarify my role in presenting these comments. Although I am a Professor of Aeronautics and Astronautics at MIT, I am submitting this response to your questions as the President of the American Association for the Advancement of Science -- an organization of 130,000 scientists and engineers and the publisher of the journal Science.

The specific areas addressed in this supplemental statement per your request include supercomputing and science, mathematics and engineering education. However, I will begin with a few brief remarks on the budget as a whole.

Overview Comments on Budget as a Whole

First, we strongly support the overall growth rate reflected in the budget request. And while it may be optimistic to expect the plan for doubling the NSF budget to the $3.2 billion level by Fiscal Year 1992 to come to fruition, we do support the objective. We acknowledge the difficult set of priority questions facing the Congress in the context of the Gramm-Rudman-Hollings deficit limitations.

However, the proposed rate of growth in the NSF budget is a major, if partial, step in the direction of redressing the problems associated with the level plateau of investment in research from the late 1960s to the late 1970s. While I do not intend to claim that this national underinvestment in research explains fully the state of our current economic problems domestically and internationally, I think a very strong case can be made that future research investments must be an important part of a total program for revitalizing our economy.

To the extent that we differ from the program and budget proposals of the NSF, it is on priorities in a few areas. I hasten to add that the areas of agreement are large and the areas of differences are relatively small. It is in science and mathematics education areas that we find ourselves in less agreement than in others.

In response to your request for comments on the future of supercomputing, I will offer a perspective which builds on several points covered in your earlier hearing on February 25. Specifically, I intend to stress the importance of supercomputers in two broad ways: (1) as part of wide-area networks and, (2) as a major influence in the transformation of research in science and engineering.

FUTURE OF SUPERCOMPUTING

The panel of witnesses which appeared before you on February 25 provided an eloquent rationale for NSF support of supercomputers in the research world. I consider the panel's testimony to be in direct support of the Subcommittee's farsighted action last year in pressing for a substantial increase in the supercomputer program.

I strongly support the arguments presented by Drs. Lester and Sugar in stressing the vital importance of supercomputing capabilities to the performance of high quality research in an increasing number of fields of science and engineering. And it is important for us to acknowledge the need to look at the acquisition of these capabilities in a national context -- not just through the lens of the National Science Foundation. The Departments of Defense, Energy and Health and Human Services are also involved in significant ways, as is industry. Supercomputing capabilities will be critical to enhancing and facilitating advances in research -- from fundamental science to industrial and governmental applications, including national security.

I would like to pick up on the general point made by Mr. Roberts of EDUCOM in his testimony about the urgent need for increased federal sponsorship and support for a national higher education computer network. More specifically, we must think seriously about establishing supercomputer centers in the context of a national network.

In this respect, during the past year NSF has taken some very positive steps both in supercomputers and in networking. Not the least of these was the reorganization of various computer-related offices at NSF under an Assistant Director for Computer and Information Science and Engineering. Another was to explicitly place in this office the program director for networking.

It goes almost without saying that communication has always been central to the world of research -- for collecting data and providing access to it; for exchanging information; for conducting meetings, discussions and seminars; for collaborating with widely separated colleagues; and, finally, for disseminating results.

However, increasingly over the past few decades, many observers have noted that the pace and complexity of research, especially collaboration involving different institutions and interdisciplinary areas, have substantially increased scientists' communication needs. Scientists and engineers in many, if not most, fields now need immediate access to data and information, to colleagues and collaborators, and to advanced computing and information services. A major point, made by various observers including D. M. Jennings (former Program Director for Networking, NSF) -- with which I strongly agree -- is that to be really useful, communication and information facilities must be integrated with the researcher's normal day-to-day working environment.

I also strongly agree with the concept of Jennings and his colleagues at the NSF that a scientist should be able to use computing and communications tools by working at an advanced graphics workstation. Via that single window, the scientist may gain access to required computing facilities and databases and communicate with peers, colleagues and researchers all over the world. It is this combination of computing, communications and information sources which we call computer networking. These networks -- when in place -- will provide the structure that combines geographically separated researchers, computing resources, and information bases into a single integrated environment.

Regrettably, we are not yet at that advanced state. The "bad news" is that, historically, computer network development and applications are best described as fragmented and incomplete. One result has been a bewilderingly wide array of different technologies and a staggering number of incompatibilities. On the "good news" side, however, there are some developments which call for encouragement and support by the Subcommittee. The NSF is focusing increasing attention on just these kinds of problems (the different technologies, formats, and incompatibilities). And very important is a growing focus on the adoption of standard computing networking protocols and on the development of the very complex software so necessary to successful network operations.

A specific element of NSF strategy involves establishing and building a national networking program under the name NSFnet. The concept of NSFnet is not only to build new networks but also to add onto existing networks; it will provide both high-speed access to supercomputers and communication among scientists all over the nation. While NSFnet has been designed initially for supercomputer users to gain access to supercomputers and to communicate with each other, it also is expected eventually to be a general-purpose computer communications network for the entire academic research community and associated industrial researchers. In short, NSFnet seeks to become a "network of networks." This strategic concept draws heavily upon the concept and experience of ARPANET which was established 18 years ago by the Defense Advanced Research Projects Agency.

Looking at all of this through the eyes of some NSF planners and others, it is possible to see the following picture beginning to emerge. An individual researcher will be working at a terminal connected either to a local super-minicomputer or to a graphics work station. These computers will be connected with a local area network (LAN) for local communications and resource sharing. The LAN itself will be connected to other LANs on the campus or nearby research parks. This collection of interconnected LANs will form a campus network. At higher levels, this campus network will be connected, via a campus gateway system, to one or more of the wide-area networks in the NSFnet to provide the researcher with access to the world, including other supercomputers, other researchers, and vast sources of data.

In recent years the National Academies of Sciences and Engineering have been examining how the various fields of science and engineering have been changing. In my testimony of February 25, I discussed several dimensions of these changes in the context of evolutionary changes in the directions, content and boundaries of traditional disciplines. I would add in these remarks that supercomputers are already beginning to have significant transforming effects on the performance of research.

These effects undoubtedly will continue to unfold and to have major impacts of the conduct and organization of science and engineering.

As I survey the supercomputer scene and its impacts, I think it is possible to say that quite clearly the United States has retained a leadership position. What is important is that we maintain the momentum which has been developed in recent years.

In concluding this section, I would like to make several summary remarks:

1. Computers of all kinds, including large supercomputers and mini-supercomputers, are becoming crucial to making new discoveries and are increasingly central to advances in most fields of science and engineering.

2. There is an immediate need to make supercomputers available to U.S. researchers as widely as possible.

3. The advanced work station will become an important feature of research performance in the years ahead.

4. Computer networks are required to link researchers via their workstations to supercomputers, to data bases, and to each other.

5. The supercomputer programs -- as supported by NSF, Defense, and the Department of Energy -- have acted as a spur and incentive for U.S. industry, in ways comparable to the federal government's support for early large mainframe computer development.

6. Universities have played an important role not only in

scientific and engineering areas related to supercomputers but also have provided a "test bed" service in assisting U.S. industry in the development of new ways to conduct, present and interpret research carried out on supercomputers. A specfic feature of this "test bed" service is that graduate students trained in university research involved with supercomputers will be an excellent source of trained manpower for industry.

I hope the Subcommittee will give its strong support to NSF's efforts aimed at establishing and building a strong supercomputer program and a national networking program. If supported at adequate levels and managed effectively, NSFnet is likely to have far-reaching, powerful positive effects on the conduct of science and engineering and advancing networking in the United States.

It is worth stressing that advances in supercomputing and networking are potentially among the greatest advantages to be gained in the performance of U.S. science and engineering relative to other parts of the world. Finally, in the industrial sector I should note that a number of leading firms, such as MCI, AT&T and Bell Labs, see networking as a central feature of their strategy for achieving growth and success domestically and internationally in coming decades.

SCIENCE, MATHEMATICS AND ENGINEERING EDUCATION

While your letter of invitation asked me to address pre-college and undergraduate education at NSF, we have taken the liberty of responding somewhat more broadly.

The Scope and Nature of U.S. Education Problems

Others have described and verified the serious state of affairs in U.S. education and underscored the gravity of the associated problems. Numerous special studies and reports cover education generally and science, mathematics and engineering education particularly. To set the stage for the remainder of my remarks, I will provide a few key excerpts which capture several essential ideas.

First, in a recent 1986 report of the Carnegie Forum on Education and the Economy, A Nation Prepared: Teachers for the 21st Century, it was stated that: "The 1980s will be remembered for two developments: the beginning of a sweeping reassessment of the basis of the nation's economic strength and an outpouring of concern for the quality of American education. The connection between these two streams of thought is strong and growing."

Second, in a report to the President of the 1984 White House Conference on Productivity, Productivity Growth: A Better Life for America, it was observed that: "Without a literate, skilled, healthy, and motivated labor force, capital and technology cannot create a productive environment."

Third, in a 1983 report of the National Commission on Excellence in Education, A Nation at Risk, it was argued that: "If only to keep and improve on the slim competitive edge we still retain in world markets, we must dedicate ourselves to the reform of our educational system."

Finally, the Task Force on Education and the Economy, Education Commission of the States, said in its 1983 report: "It is our judgment that a high general level of education is perhaps the most important key to economic growth."

Clearly, education is increasingly seen, along with international business and trade, as a key area of concern in our search for solutions to the problems we associate with our diminished competitiveness. Perhaps it is no exaggeration, then, to suggest, as has the National Journal, that we have a large "education deficit" as well as a "budget deficit."

Our "education deficit" is across the board -- in teachers and teacher training, in learning methods, in educational motivation, in school organization, in curriculum content and structure, and in educational research. All of this presents a grim picture and a worrisome outlook. However, before I go ahead with my discussion on specific aspects of science, mathematics and engineering education, I would like to offer several cautionary notes on how we proceed from here.

- The range of problems is so broad and their roots so deep that we may be tempted to throw up our hands and say "let each school district or state worry about its own special problems. It's much too complicated to do so nationally." Yes, the states and the schools have a central role but, as I will argue, the federal government also has a vital role to play.

- The gravity of the problems may lead to political pressures for rapid action -- of any kind. My concern is related to our national predilection for "short-term" solutions for problems of any kind.

- I am concerned that the growing linkage between our international competitiveness and education might become the only reason for supporting a broad, national effort in education. Our efforts to improve the quality of our educational system should be more broadly based than on this one dimension. While the connection is important, and it is reasonable to argue for increased educational support on such grounds, we must not lose sight of other objectives such as those related to the quality of life -- as a nation and as individuals.

Budget Overview of NSF and the Department of Education

A review of the total budget numbers for NSF and the Department of Education reveals that:

- On what seems to be a definite overall positive note, the NSF shows a proposed increase for a newly defined informal grouping of programs called "education and development of human resouces." Its budget numbers show an increase of $91 million from $182 million in FY 1987 to $273 million in FY 1988.

- On the strongly negative side -- at least from a budgetary point of view -- is what seems to be a virtually total withdrawal of the Department of Education from science and mathematics education. However, almost worse than the withdrawal has been the policy instability exhibited in implementing the Education for Economic Security Act (EESA) of 1984.

It is difficult to understand what anybody hopes to achieve in a program that shoots up to $100 million in FY 1986, drops to less than $80 million in FY 1987 and then to zero for FY 1988. Moreover, congressional insistence on a formula approach to grants has led to partitioning the total funding into what often became ineffective small grants of a few hundred dollars. Surely we can do better in terms of stability, priority setting, and long-term commitment to solving serious problems in the areas of science and mathematics education.

The NSF Five-Year Strategic Plan for Science and Engineering Education

We have reviewed NSF's "Strategic Plan FY 1987 -FY 1991: Enhancing the Quality of Science, Mathematics, and Engineering Education in America," dated February 10, 1987 which was recently submitted to the Congress as required by the Education for Economic Security Act of 1984 (P.L. 99-159). We find that:

- It represents important steps in the right direction and seems to draw carefully upon the results of the many studies and reports of recent years concerning science, engineering and mathematics education.
- It describes in considerable detail the kinds of activities and programs which will be necessary for our nation to undertake in attacking and solving serious educational problems, and presents them in an NSF context. The listing is rather complete.
- It does not, however, provide a clear statement of balance or priorities of science and mathematics education

either as part of the total NSF program and budget or among the various parts of the "education and development of human resources." Specifically missing are plans beyond FY 1988, including objectives and general budget targets over the five-year time horizon.

We hope that it will be possible for NSF to extend its analysis and planning in these areas when it eventually receives the strategic studies required by the Congress over two years ago. On this point of strategic planning we do think that NSF has come a long way in the past several years. Director Bloch and the National Science Board are to be commended on this score.

Some Long-Term Perspectives on the Current Budgets for Science and Engineering Education

It may be useful to review in roughly chronological order several historical perspectives on how we came to our current state of affairs. It is essential to understand that in one form or another we have been debating issues related to science and mathematics education for at least three decades.

- Just thirty years ago, in response to Sputnik, we reacted with alarm to what was seen at the time as a crisis of colossal proportions. One of our responses, along with large new investments in space research and technology, was to make large, new investments in science and mathematics education -- through NASA, the Department of Defense, and the National Science Foundation. (A landmark piece of legislation was the National Defense Education Act of 1958.)

- However, after that initial spurt of funding, interest and enthusiasm for support of science and mathematics education diminished, although during the 1960s education was allocated a sizeable part of the total NSF budget -- in the 27-35 percent range --peaking at a level of $135 million per year in 1968 (See Table 1).

- During the 1970s, interest and enthusiasm continued to decline -- except in certain congressional circles such as your Subcommittee. You became one of the guardians and guiders of the science education program.

- Also, during the mid-1970s science education -- particularly certain curriculum development efforts -- became embroiled in political controversy as several social science courses were attacked by various political and religious groups. Congress acted imprudently, I think, by terminating support for all curriculum development by the NSF. We are still paying the price in our schools for that turn of events in the form of outmoded and ineffective texts and learning materials.

Another part of the price we paid as a nation for pulling out of curriculum development efforts was that we lost the momentum and value of faculty from research universities being involved in the development of curricula and related materials. I believe it essential that the research community be seriously involved in these efforts. This involvement brings together both researchers and educators in ways that benefit both groups and their work. These interactions also provide ways for linking and grounding research knowledge with practical applications of that knowledge in schools.

- As the 1970s drew to a close, investment in science and mathematics education remained in the "backwaters" and the scars from the political battles of the mid-70s still showed. Yet evidence was beginning to mount that all was not well in science and mathematics education. Further, a new dimension was added to growing general concern: problems in engineering education.

- With the coming of the 1980s and the Reagan Administration, there was strong opposition to the previous role of the federal government in education. There was a determination to eliminate any federal role in science, mathematics and engineering education at NSF or anywhere else in the federal government. Thus was set into motion the series of decisions which led to the near demise of science education at NSF, except for the graduate fellowships.

- Only through the intercession of Congress -- Democrats and Republicans alike -- was nearly a total elimination of education averted at NSF. But very little in the form of organization or programs survived in 1981 and 1982. Mainly through Congressional prodding and the support of a few Administration officials, the science, mathematics and engineering education areas at NSF have been gradually recovering -- far too gradually in the view of many observers, including ourselves.

- Some observers and participants point to the fact --

noted above -- that in earlier crisis years science education accounted for at least 25 percent of the NSF budget. Drawing on that benchmark, and concluding that today's problems are as serious as those in the 1960s, it is argued that the NSF science and engineering education budget should be in the range of $400 million in the FY 1988 budget as compared with the $115 million requested. It is also observed by some that reports of the National Science Board and other responsible parties have identified needs for various programs which would likewise add up to about $400 million at this time for FY 1988.

- This chronology clearly shows that science and mathematics education -- and more recently engineering education --have a history of "starts and stops," changing focus, and policy instability. As we look at the current situation there is little doubt that we have been in a low investment mode for a long period of time. Major investments over an extended period of time aimed at achieving agreed-upon objectives will be necessary if we are to have any hope of achieving significant progress in solving the array of problems facing us.

A key consideration for Members of the Subcommittee and your colleagues in the Congress is a judgment on how serious is the educational crisis in this country with respect to science, mathematics and engineering education. A question needs to be asked: "Are things as bad as they were in the late 1950s and early 1960s? Or have we made significant progress in spite of the currently documented problems?"

My own view is that we have made progress. Although grave problems exist, things are not as bad as they were in those distant years of the late 1950s. And most surely, we need to avoid the "crisis mode of response" which followed Sputnik. More directly, we do not need crash, catch-up programs aimed mostly at overtaking the Japanese or the Russians or other U.S. competitors.

Of far greater value, I think, would be a policy of sustained and substantial commitment by the federal government in a catalytic role. The focus of this role over the next ten to twenty years could be to make specific advances and improvements along a broad front in cooperation with the states and localities. Perhaps a model -- in terms of the long-term commitment but without the large federal financial role --could be the national interstate highway system we committed to during the Eisenhower Administration.

Over thirty years later we are still working at meeting that commitment, but the magnificent achievements have helped transform the country. Such a federal commitment in science, engineering and mathematics education would serve as the catalyst for comparable sustained effort on the part of the states, localities and private sector parties.

Specific Comments in the FY 1988 Budget

In reviewing the FY 1988 budget request in the context of the five-year strategic plan discussed earlier, we find ourselves rather puzzled. While we acknowledge the NSF presentation which shows the earlier mentioned increase of $91 million for "education and development of human resources," we are concerned to see that no increase whatsoever has been allocated to pre-college education.

While the support for pre-college education appears in the text of the five-year strategic plan and in the public testimony of Director Bloch before your Subcommittee, the proposed budget numbers for pre-college science and mathematics education do not reflect an appropriate level of budgetary commitment. While we are not calling for massive "Sputnik-like" federal action, it is important to acknowledge the vital need for significant responses and investments to cope with the serious deficiencies which have been amply documented time after time in recent years at the pre-college level.

Moreover, aside from the intrinsic need issue, there is the message sent by the "no-growth" action. In a environment of high growth rates throughout much of NSF's budget, there is the inevitable conclusion about the relative lesser importance of pre-college education. The NSF has had enough problems in the past of dealing with the perception that it really did not want to be bothered with this responsibility. Since this does not seem to be the case under the current NSF leadership, we are led to conclude that the "no-growth" decision was a mistake which the agency would cooperate with the Subcommittee in redressing.

The drastic drop-off in pre-college support for science and mathematics education by the Department of Education is one more reason why we must be concerned about the "no-growth" decision for pre-college programs in the NSF's budget request.

It is time to acknowledge firmly and unequivocally that national policy should be to help establish, nuture and encourage the development of a consistent, integrated program of science and mathematics learning from kindergarten through high school. There must be a commitment to persist in our programs at the federal level long enough for change to occur, especially in the areas of curriculum development, teacher training, and the research base in education. Particular emphasis must be placed on the R&D portion of the science education budget.

With respect to curriculum development, we cannot just mail out new curriculum materials to teachers and expect that the materials will be utilized. We know that approach does not work. New training programs must be devised and implemented in cooperation with the states and school districts. Closer attention must be given -- using research results -- to what works best in teacher training. And given the scarcity of resources, we must avoid methods of teacher training that are not cost effective. More emphasis needs to be placed on an approach to teacher training which is based on continuing education on school premises or in local areas. We need to focus on the design of technologies aimed at upgrading knowledge of content and the methods of teaching it within the school and classroom. NSF has an array of capabilities that would be important to such an effort.

It is quite possible to use the concept of "resource centers" for reaching out with continuing education for local school and school district teachers. For example, it might be worthwhile to explore the use of a model based on the current Engineering Research Centers as one way of reaching out to high schools.

While there is no question -- nor was there ever one despite what some critics have said in the past -- that this leads to federal "control" of education, it does underscore the importance of the federal government in performing educational research and development, investing in curriculum development, and pioneering in new teaching and learning appproaches.

The plain facts are that the fifty states and the 16,000 school districts in this country cannot replicate individually all such activities. Yet the implementation of specific programs will rest firmly in the hands of the local schools, their school boards and the states.

At this point I might address a specious argument sometimes used in opposing a federal role in education: since the local school systems involve expenditures of many billions, how can the federal government expect to have any impact with the expenditure of relatively few NSF dollars. Such arguments ignore the fact that the great part of those billions is for teacher and administrative salaries. The amount spent by any given school district on research or course development for science and math education -- or any other subject -- is tiny or non-existent.

This is where the federal effort has high leverage and fills an urgent need in its role as a catalyst.

Further, I would underscore the obvious: pre-college science and mathematics education is where we must begin to insure an adequate flow of informed citizens, candidates for careers in science and engineering, and those who will be in the management and professional ranks of organizations which will depend on advances in science and technology for their well-being and survival.

I want to emphasize that in order for students to enter programs in science and engineering they must have gone through demanding programs in high school. And that for them to have chosen such programs in high school, they must have had the kinds of programs and teachers at the middle school level that provided the right kind of motivation.

Let me now turn to another facet of our "education deficit:" those issues surrounding the education of women and minorities in science, mathematics and engineering. These issues have been discussed and debated in terms of equity and fairness for more than a decade. While equity and fairness are still important, it is becoming clear that national need for the talents of women and minorities in science and engineering is becoming the driving force.

As Figure 1 shows, the demographic trends to the year 2000 show a significant dropoff in the numbers of 22-year olds and 30-year olds in the U.S. population. This is the pool from which we obtain our scientists and engineers. Figures 2 and 3 show dramatic reductions in the production of scientists and engineers at all levels if we maintain 1984 participation rates.

There is no doubt that we must tap this pool of candidates if we are to have enough qualified scientists and engineers in the future. We must continue to reach for answers to the under-achievement problems and the under-participation of women and minorities in science and engineering. This means we need on-going research on these issues; we need the development of models and programs which will work. Also, we need more evaluation of various models and dissemination of the results on "what works and why."

Key practical questions include: how can we encourage greater experiences in science and mathematics by young people in these groups? How are we going to get more science and mathematics teachers from the talent pool of women and minorities? NSF has done some exemplary work in the area of women and minority participation but it may be time for a more active, aggressive approach to finding answers to the kinds of questions I have just posed.

To summarize on science, mathematics and engineering education:

- We support the NSF budget request and believe it represents a sound move as part of an overall program for improving the state of our economy. Only with respect to the plans and budget request for pre-college education do we differ from the Administration's request. We believe the case is overwhelming for a moderate increase to the range of that allocated for undergraduate education as the beginning of a long-term commitment.

- NSF should set a number of specific goals, either alone or in cooperation with the Department of Education (depending on the future role of the Department), in science, mathematics and engineering education. Examples of such goals could be:

(1) In ten years achieve a significant increase in student performance in mathematics so that we rank closer to the top internationally. Not only would this achievement give us a stronger underpinning for careers in science and engineering but also would permit us to escape the acute embarassment we should be feeling over our present low performance.

(2) In ten years achieve a complete overhaul and modernization of mathematics and science curricula in grades K through 12.

(3) By the year 2000, in close cooperation with the states and school districts, develop and make available appropriate equipment to support effective science teaching in grades K through 12.

(4) Within five years develop a core of regional "resource centers" for science and mathematics teachers in all parts of the country. Continue to expand such centers in number and capabilities over the next fifteen years.

(5) Develop the programs that will, within ten years, lead

to a doubling of the number of science and mathematics teachers from minority groups.

(6) Explore the feasibility of networking science and mathematics teachers along the lines of researchers in NSFnet.

(7) Establish and support for the long-term an adequate R&D base in science, mathematics and engineering education.

Such suggestions are only illustrative. We strongly recommend that the pending strategic planning of the NSF be made more explicit in terms of objectives, priorities and proposed budgets. Moreover, unless this strategic outlook is adopted and supported nationally, the prospects for any significant progress in solving the previously outlined problems are not promising.

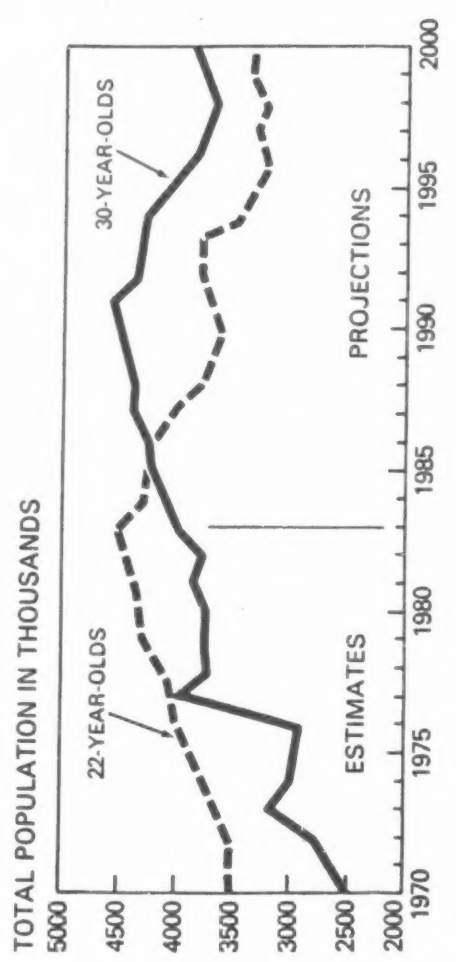
The states and school districts can do and, indeed, are doing much to improve the overall quality of education by increasing teacher salaries, raising standards for teachers and students alike, and by modernizing school organizations and physical plants. Yet, there remain the crucial federal roles as the performer of education research, the catalyst, the networker, and the supporter of the development of new materials and learning methodologies.

Thank you for the opportunity to present these views.

FIGURE 1

FIGURE 1

PROJECTIONS OF 22-YEAR-OLDS AND 30-YEAR-OLDS IN THE U.S. POPULATION



SOURCE: BUREAU OF THE CENSUS.

FIGURE 2

FIGURE 2

FUTURE S/E BACCALAUREATES, ASSUMING CURRENT PARTICIPATION RATES

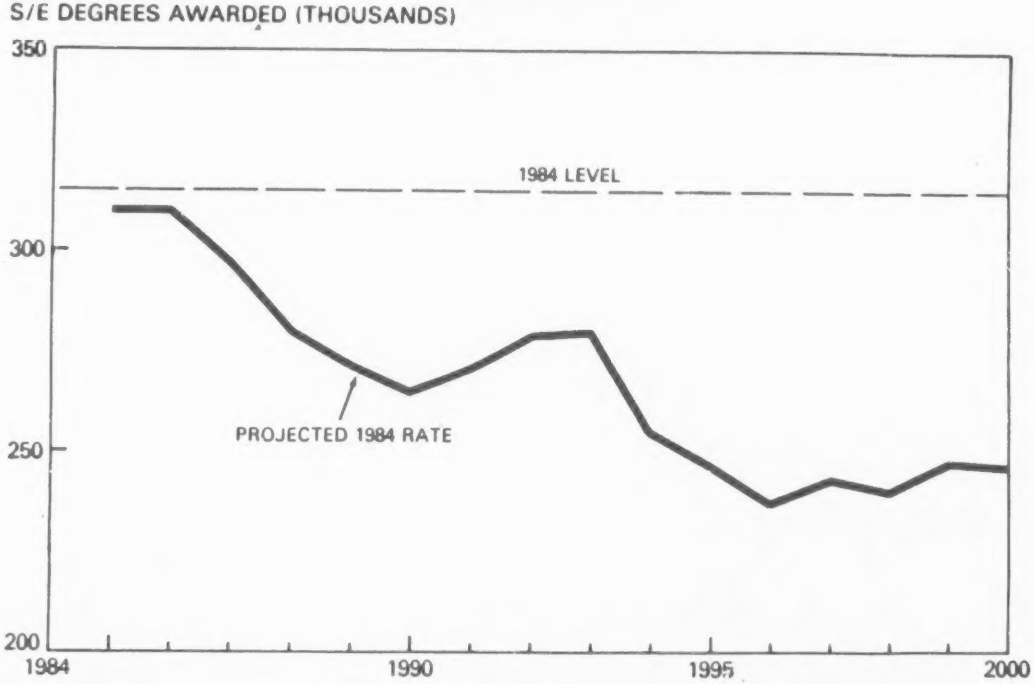


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FIGURE 3

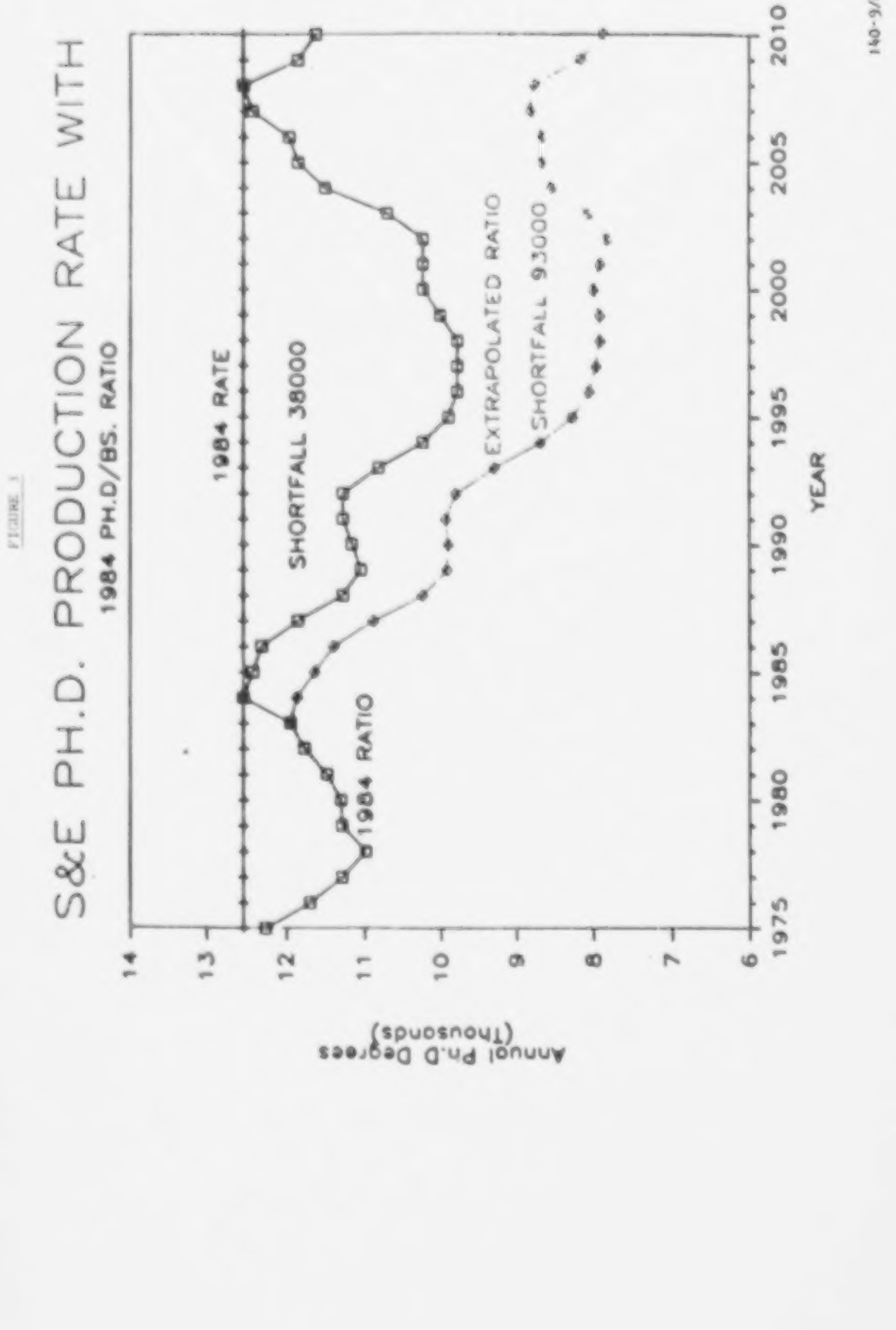

FIGURE 3
S&E PH.D. PRODUCTION RATE WITH
1984 PH.D/BS. RATIO
1984 RATE
SHORTFALL 38000
1984 RATIO
EXTRAPOLATED RATIO
SHORTFALL 93000
Annual Ph.D Degrees (Thousands)
14
13
12
11
10
9
8
7
6
1975
1980
1985
1990
1995
2000
2005
2010
YEAR
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TABLE I

Estimated National Science Foundation Science Education Obligations By Function, By Year
(in millions of dollars)*

				Functions*									
Fiscal Year	Total NSF dollars	Total SE dollars	Percent SE of Total	R&D**		Students		Teachers		Institutions		Science and Society	
				%	$	%	$	%	$	%	$	%	$
1952	3.47	1.54	44.4	0	0	99.7	1.535	0.3	0.005	0	0	0	0
1953	4.42	1.41	31.9	0	0	98	1.38	2	0.03	0	0	0	0
1954	7.98	1.89	23.7	0	0	95	1.798	5	0.08	0	0	0	0
1955	12.49	2.10	16.8	3	0.06	88	1.85	10	0.21	0	0	0	0
1956	15.99	3.52	22.0	0.4	0.01	67	2.36	32	1.13	0	0	0	0
1957	38.63	14.30	37.0	7	1.00	21	3.00	72	10.30	0	0	0	0
1958	49.97	19.20	38.4	9	1.73	22	4.22	69	13.25	0	0	0	0
1959	132.94	61.29	46.1	14	8.58	24	14.71	62	38.00	0	0	0	0
1960	158.60	63.74	40.2	14	8.92	25	15.94	60	38.24	0	0	0.5	0.32
1961	174.98	63.44	36.3	15	9.52	24	15.23	61	38.70	0	0	0.5	0.32
1962	260.82	83.60	32.1	12	10.03	24	20.01	61	51.00	3	2.51	0.4	0.33
1963	320.75	98.72	30.8	15	14.81	27	28.65	55	54.30	3	2.98	0.4	0.39
1964	354.58	111.23	31.4	15	16.68	30	33.37	51	56.73	4	4.43	0.4	0.44
1965	415.97	120.41	28.9	13	15.65	36	43.35	44	52.99	7	8.43	0.3	0.36
1966	466.43	124.30	26.7	13	16.16	42	52.21	39	48.48	6	7.48	0.1	0.12
1967	465.10	125.82	27.1	17	21.39	38	47.81	38	47.81	6	7.55	0.3	0.38
1968	495.00	134.46	27.2	16	21.51	36	48.41	37	49.75	10	13.45	0.2	0.27
1969	400.00	115.30	28.8	18	20.75	37	42.66	34	39.20	12	13.84	0.2	0.23
1970	440.00	120.18	27.3	15	18.03	38	45.67	37	44.47	9	10.82	0.2	0.24
1971	513.00	98.81	19.3	23	22.73	38	37.56	35	34.58	4	3.95	0.4	0.40
1972	622.00	86.10	13.8	33	28.41	28	24.11	28	24.11	12	10.33	0.8	0.69
1973	645.74	62.23	9.6	34	21.16	34	21.16	21	13.07	11	6.85	1	0.62
1974	645.67	80.71	12.5	36	28.79	22	18.13	25	19.96	14	11.61	3	2.42
1975	693.20	74.03	10.7	35	26.65	26	19.00	24	17.90	13	10.00	2	1.49
1976	724.40	62.50	8.6	17	10.63	36	22.50	6	3.75	37	23.13	4	2.50
1977	791.77	74.30	9.4	15	11.15	31	23.03	11	8.17	38	28.23	5	3.72
1978	884.91	73.96	8.6	12	8.83	29	21.45	14	10.35	38	28.10	7	5.18
1979	928.40	80.00	8.6	14	11.20	28	22.40	13	10.40	36	28.80	8	6.40
1980	986.25	77.19	7.7	18	15.25	25	21.18	14	11.86	34	28.80	9	7.62
1981***	1,041.80	70.70	6.8	—		—		—		—		—	

*The functional categories of obligations are exemplified as follows: Students includes programs such as fellowships and precollege student science training. Faculty includes programs such as teacher institutes and faculty short courses. Institutions includes programs such as ISEP (equipment purchasing), LOCI (Local Course Improvement), and CAUSE (Comprehensive Assistance to Undergraduate Science Education). Science and society includes programs for improving the public understanding of science and studying the ethical issues in science and technology.

**Until 1977 development projects received most of the R&D funding.

***1981 Breakdown of obligations not available at time of printing.

Source: Directorate for Science Education, National Science Foundation, unpublished data.

American Chemical Society

OFFICE OF THE
BOARD OF DIRECTORS

1155 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036
Phone (202) 872-4600

Ernest L. Eliel, *Chairman*

March 23, 1987

The Honorable Doug Walgren
Chairman
Subcommittee on Science, Research and Technology
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Recent events within both the Congress and the Administration, have focused on the central role of education and basic research in advancing the economic competitiveness of the United States. As one means to achieve the excellence for which the Nation is striving, the American Chemical Society urges the Subcommittee to support the National Science Foundation's budget at least at the Administration's requested level of funding. Further, Congress must sustain the five-year commitment to double the Foundation's budget by FY 1992 to develop a scientifically educated public and a knowledge base upon which this Nation can build its economic future.

The Society's other major comments concerning the proposed NSF budget are:

- The ACS is pleased that there are proposed increases for the Divisions of Chemistry; Materials Research; and Chemical, Biochemical, and Thermal Engineering.

  However, funding of NSF's Chemistry Division has been and, unless action is taken, will continue to be inadequate to exploit the enormous research potential of chemistry as delineated in the National Academy of Sciences/National Research Council Report, Opportunities in Chemistry.

  Also, funding levels proposed for NSF's Materials Research and Chemical, Biochemical, and Thermal Engineering Divisions are insufficient to meet the needs of the academic infrastructure in these areas.

- The impact on the health of various scientific fields by the Science and Technology Centers approach as well as other Foundation-wide funding mechanisms should be monitored and evaluated.

- Although the ACS applauds the Foundation's $115.0 million commitment to the Science and Engineering Education Directorate, the Society also believes that increased support of $12.0 million over the budget request is urgently needed for enhanced activities. This proposed increase should be new monies added to the FY 1988 budget request for the Foundation.

The American Chemical Society would be pleased to discuss its concerns further with the Subcommittee. The accompanying Appendix outlines the above points in greater detail.

Sincerely yours,

Ernest L. Eliel

Ernest L. Eliel

Appendix

cc: Other Members, House Subcommittee on Science,
Research and Technology

APPENDIX

National Science Foundation Budget

Technological progress is rooted in our Nation's investment in research and education, particularly at universities and colleges. Since the National Science Foundation provides a majority of the federal support for basic research in certain disciplines performed in academia, the health of these institutions will be highly dependent on real growth in the NSF budget. The American Chemical Society supports the federal commitment to a doubling of the budget of the National Science Foundation in five years starting with FY 1988.

Chemistry Division

Although the ACS is pleased that the Chemistry Division receives an increase in the FY 1988 budget request, we also are dismayed at the insufficient support for the chemical sciences within this budget. In proportion to its contribution to the economy, chemistry has been and is currently underfunded. Historical tables show that, in constant 1972 dollars, NSF funding for the Chemistry Division during the period FY 1985-88 increases an average of less than one percent annually. Recognizing that it will be difficult to remedy this situation for FY 1988, the Society urges that a higher priority be given to funding for chemical research in future NSF budgets.

Chemistry is a central discipline from which other sciences flow. The chemical sciences are a major contributor to high technology industries, such as computers, electronics, robotics, and biotechnology. Chemists and chemistry are needed to synthesize, characterize, and transform advanced materials, such as superconducting polymers, composites, and ceramics. An estimated 40 percent of the U.S. GNP (including food production and energy technology) is derived from the chemical sciences. During the past five years, the chemicals and related products industries have brought the U.S. a favorable trade balance of $8.8 billion per year. Over 130,000 chemists are employed by U.S. businesses, more than any other scientific discipline. Increased scientific and technological leadership by the U.S. will depend upon renewed support for research in the basic chemical sciences as well as support mechanisms that provide experienced personnel for the chemical and allied industries.

The NSF FY 1988 budget request for the Chemistry Division is 9.9 percent above the FY 1987 level, compared to the overall increase for the Research and Related Activities Directorates of 16.3 percent. To understand the significance of the proposed Chemistry budget, prior funding patterns and future potential growth must be examined.

FY 1986

Due to the triggering of the provisions of the Gramm-Rudman-Hollings Balanced Budget and Emergency Deficit Control Act, a 4.3 percent budget cut was sustained by the Chemistry Division during FY 1986. The Division dealt with this reduction by delaying purchases of major instrumentation and shortening the period of funding of some continuing grants. This reduction was completed with the expectation that future funding increases would make up the difference.

FY 1987

In FY 1987, NSF proposed an initiative in the chemical sciences in direct response to the many opportunities for research advances and societal benefits delineated by the National Academy of Sciences/National Research Council (NAS/NRC) Report, Opportunities in Chemistry. Unfortunately, the proposed increase for the Chemistry Division was halved due to a cut associated with action on the NSF budget request. Further, delayed approval of appropriations made it extremely difficult for research investigators to find funding elsewhere in order to maintain continuity and stability in research groups.

Within this revised budget for FY 1987, the Division supports agency-wide initiatives such as collaborative research, the Experimental Program to Stimulate Cooperative Research, Presidential Young Investigators, biotechnology, computer science and technology, and development of human resources activities. The Special Projects activity, which includes multidisciplinary research, and the Chemical Instrumentation Program received the largest increases over the FY 1986 level. In order to expand activities in these agency-wide areas, most continuing grant amendments will be reduced in FY 1987 below the levels provided in FY 1986. Also, the number of awards is likely to drop below the FY 1986 level. The ACS has learned that senior investigators have had to cut graduate student or postdoctoral support to accommodate this reduction in funding.

FY 1988

With the FY 1988 budget, the Chemistry Division is still playing catch-up to try to adequately support the individual investigators while simultaneously funding Foundation-wide activities. These latter activities include exciting areas of multidisciplinary research--chemistry of life processes and materials chemistry, with a new emphasis on the chemistry of thin films and interfaces. (Interfaces are the physical junctions where two different substances or phases of one substance meet.)

The proposed increase for FY 1988 focuses largely on agency-wide activities and on increasing the number and amounts of stipends for postdoctorals and graduate students. This increase provides inadequate support to chemistry's underlying subdisciplines; too many excellent proposals from individual research investigators will be unfunded or underfunded. A five-year plan in shared instrumentation--proposed in FY 1987 to fund ongoing maintenance and operations--also will be on indefinite hold.

Under the above funding scenario, the enormous research potential indicated by the NAS/NRC Report on Opportunities in Chemistry will not be fully exploited. Chemistry's contribution to the Nation will not be fully realized unless the base funding support for research in the chemical sciences is increased and maintained in the future.

Materials Research and Chemical Engineering

As mentioned previously, the chemicals and related products industries still have a positive trade balance. This strong showing is related to the academic infrastructure in the fields of materials science and chemical engineering as well as in chemistry. These interrelated fields are connected to industrial needs and their communication channels with industry are well-developed. This communication is an important factor in technology transfer from university to industry.

The health of academic research and education in materials science and chemical engineering is essential to continued U.S. economic competitiveness in the chemical and allied industries. NSF is a primary player in assuring this health: the Foundation funds about 50 percent of the materials research and 84 percent of the chemical engineering research conducted with federal funds in academia.

The American Chemical Society is encouraged to see that increases are proposed for these fields in NSF's FY 1988 budget request. However, these increases do not reflect the importance of these fields to new technological advances in biochemicals, electronics, and advanced materials. Of grave concern to the Society is that the 10.1 percent growth proposed in FY 1988 for NSF's Materials Research Division and the 10.9 percent growth in the Chemical, Biochemical, and Thermal Engineering Division is inadequate to maintain the momentum of academic activities in these areas. In fact, the latter Division does not share in the large increase of 25.7 percent proposed for the Engineering Directorate. Both these Divisions have pressures on them, equivalent to those described for the Chemistry Division, which draw resources away from research project programs to agency-wide activities.

The Materials Research Division has a number of programs such as Polymers and Solid State Chemistry that support research that employs the principles and practices of chemistry. The Materials Research Division also supports the Materials Chemistry initiative, along with the Chemistry Division, and a Materials Processing initiative to be carried out jointly with the relevant engineering disciplines.

The Chemical, Biochemical, and Thermal Engineering Division has several thrusts in process engineering. A new emphasis is on advanced modes of process operation to produce high-valued, fine chemicals. Also, enhanced research is being funded on thermal processing in conjunction with the Materials Engineering and Processing program. These research thrusts indicate the continuum of chemistry, materials science, and chemical engineering, and their importance to providing the knowledge base and trained personnel needed by both established and new industries.

Multidisciplinary Research Centers, Individual Investigators, and Other Funding Mechanisms

The American Chemical Society commends the Foundation for proposing its innovative science and technology research centers concept. NSF foresees that the multidisciplinary research centers approach will accelerate scientific progress in areas that are intellectually challenging as well as economically promising, will involve strong industrial participation as well as technology transfer, and will provide unique opportunities for education and training.

The centers are expected to attract funds from contributors such as industry and state and local governments. These contributors may participate in the research conducted under these centers, and in the determination of the relevance of problems to industrial technologies. The centers approach will help to address instrumentation needs in academia since it will provide for the acquisition and sharing of high-cost instruments and other equipment as well as for instrumentation development. Additionally, numerous scenarios could be drawn for the establishment of other mechanisms such as visiting faculty and cross-directorate postdoctoral appointments to enable faculty and students to gain experience at these centers.

The factors that make this approach work will vary considerably from discipline to discipline and will depend on the industries involved. NSF already has invaluable experience from the Engineering and Industry/University Cooperative Research Centers as well as from multidisciplinary groups. The ACS sincerely hopes that the Foundation's expectations in this area are fulfilled.

However, the ACS would like to raise some concerns. The Society believes that NSF should closely monitor the Science and Technology Centers approach and other agency-wide activities to determine any impacts on the health of the disciplines, in particular on individual investigator research. While strong disciplinary basic research is an important component of education and training, and provides a necessary foundation for multidisciplinary, multi-investigator research, the centers and other collaborative research groups will change the nature of the research environment. This change should be carefully observed and then evaluated.

Multidisciplinary, multi-investigator research and other Foundation-wide activities will compete for limited research dollars with more "traditional" disciplinary program elements, including individual investigator awards. The Foundation must continue to select proposals for funding on the basis of excellence. Consideration should be given to the quality of research being conducted regardless of the mechanism of support. Finally, the success of each Foundation-wide activity must be judged in order to decide how best to allocate NSF resources.

Science and Engineering Education

The American Chemical Society applauds the Foundation's proposed increase of 16.1 percent for the Directorate for Science and Engineering Education (SEE). This increase is an indication of NSF's strong commitment to science and engineering education. The Society recognizes, as does the Foundation, the extreme importance of designing programs that address the educational needs of those students who do not intend to become professional scientists, mathematicians, and engineers as well as the needs of the many students who do. The Society commends the Directorate for the thoughtful and timely manner in which new programs have been initiated and implemented over the past several years. Especially noteworthy is the recent emphasis on middle and elementary school science and mathematics.

The leadership exhibited by NSF also has sensitized scientists from business, industry, and academe to their opportunities and obligations to interact with government and the science, mathematics, and engineering education establishment to promote standards for science and mathematics instruction in the Nation's schools. Many scientific and technological associations have created their own infrastructures to address school concerns at the local level. These organizations view the NSF as the only appropriate focus for the continuum of science and mathematics education programs from kindergarten through high school, to college and beyond.

In ACS's view, the greatest problem facing precollege science and mathematics education is the shortage of subject-matter competent teachers. This situation is being addressed by SEE through programs that focus upon improving the preservice education of incoming science and mathematics teachers, as well as improving the performance of teachers now in the classroom. Both approaches are vital. However, the Society believes that the funding of these efforts in the FY 1988 budget, which is level with FY 1987, will only begin to relieve national needs in this area.

The ACS also is very concerned that, within the SEE Directorate, no new funds have been proposed for curriculum development at the precollege level, nor at the college level. At the precollege level, there is a need to support the development of innovative courses designed to attract more students to the sciences. Most existing course offerings are at least twenty-five years old and are a result of the post-Sputnik "golden age" of concern for science education. Not only has science moved forward since that time, but so has our understanding of how to teach science to a wider spectrum of students. Greater efforts are needed now to ensure that innovative courses are produced for all the sciences.

Given our appreciation of the continuum that is science education, the ACS believes that curriculum development at the precollege level will, sooner or later, catalyze much needed reform at the college level. Thus, the Society was disappointed that the FY 1988 SEE budget did not contain funds to promote forward planning and to explore the need for college science curriculum development, particularly for the first two years of the undergraduate experience. The ACS applauds the $7 million assigned to the research directorates for curriculum development in calculus and engineering, but believes these activities are not sufficient at this time.

The ACS is gratified that NSF is responding to the recommendations of the recent "Report of the NSB Task Committee on Undergraduate Science and Engineering Education." The Society is convinced that the concerns expressed in this document accurately describe a rapidly deteriorating situation in our institutions of higher learning. Given the well-recognized deficiencies in laboratory instruction, faculty preparedness, and curricula, ACS firmly supports the establishment of NSF programs to strengthen undergraduate science, mathematics, and engineering education. The Society believes that it is very important to involve the research community in efforts to improve undergraduate science education as it is to involve the SEE Directorate. However, the ACS would caution the Foundation to structure its efforts in support of undergraduate education in as multi-faceted a manner as possible. Undergraduate research opportunities are important, but they satisfy only a part of the need at the undergraduate level.

Although the American Chemical Society applauds the addition of $3 million to the SEE Directorate in support of faculty enhancement, the Society is concerned that the College Instrumentation Program will receive only level funding from FY 1987 to FY 1988. The budget information available does not make it clear to what extent the funds in the research directorates will be utilized for faculty enhancement and undergraduate instrumentation.

Given the budget exigencies under which NSF must operate, the Society recognizes that the SEE role must be limited to leadership activities, and to the support of model programs. Nevertheless, in spite of the federal budget deficit, the Nation must continue to expand its commitment to science, mathematics, and engineering education in order to advance as a modern society. The relationship between technological literacy and economic competitiveness in world markets is now well recognized. History has taught us that once the full extent of a problem is recognized, nations must plan for its long-term solution. Thus, the ACS supports the breadth of programming within the SEE Directorate, including the proposed $16 million increase for new program initiatives. The Society however urges an increase of $12 million in funding beyond that proposed, distributed to enhance the areas indicated above. This increase in funding for SEE should be new monies added to the FY 1988 budget request for the National Science Foundation.

American Chemical Society
March 23, 1987

CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS
1200 SEVENTEENTH STREET, N.W., SUITE 520, WASHINGTON, D.C. 20036 • [202] 887-6166

STATEMENT OF THE CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS (COSSA)

Howard J. Silver
Associate Director for Government Relations

on the

FY 1988 BUDGET FOR THE NATIONAL SCIENCE FOUNDATION

Prepared for the

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

The Honorable Doug Walgren, Chairman

March 27, 1987

American Anthropological Association • American Economic Association • American Historical Association • American Political Science Association
American Psychological Association • American Sociological Association • American Statistical Association
Association of American Geographers • Association of American Law Schools • Linguistic Society of America

The Consortium of Social Science Associations (COSSA) represents more than 185,000 American scientists across the full range of the social and behavioral sciences disciplines. It functions as a bridge between the research world and the Washington community. A list of COSSA Members, Affiliates, and Contributors is attached.

COSSA would like to take this opportunity to express our appreciation to the Subcommittee for its past strong support for our disciplines at the National Science Foundation. What follows are our comments on the proposed FY 1988 budget for the NSF and some of the issues raised by that budget.

We strongly support the proposed overall increase of 16.5% in the FY 1988 budget and the proposed doubling of the Foundation's resources by 1992. In this era of budgetary restraint, the strong commitment of the administration to invest in this nation's scientific endeavors reflects an understanding of the importance of basic research to America's future as a great nation. Reducing that commitment will decrease the nation's ability to compete. We urge the Congress to accept the full increase.

The 16.2% increase for Research and Related Activities is also welcome. We strongly urge the maintenance of that increase during the Subcommittee's deliberations. The 13% increase for the Social and Economic Division and the 12% increase for the behavioral programs of the Behavioral and Neural Sciences Division reflect continued NSF support for these programs. These increases will finally return the social and behavioral science programs to their FY 1980 levels in constant dollars.

While it is long past time for this level to be reached, it is no longer a sufficient goal. In FY 1981 President Carter's last budget for NSF requested $1.15 billion. It included $40 million for social and economic science and $39.5 million for behavioral and neural sciences. In FY 1988 the total NSF budget request is $1.89 billion. Yet the request for social and economic science programs is only $36.0 million and for behavioral science programs is only $25.8 million. Thus, while funding for NSF has increased significantly in the past eight years, the share of those funds going to social and behavioral science research has decreased. COSSA believes that the Subcommittee should increase funding so that 5% of the Research and Related Activities budget goes to social and behavioral science research. This would mean adding $14 million to the FY 1988 proposed funding. We believe this is a justifiable goal given the intellectual vitality and ferment in these sciences and their importance to the nation.

The release later this year of the report of the National Research Council's 10 Year Outlook Study for the social and behavioral sciences will provide a significant picture of the vitality, ferment and contributions of these disciplines. Although not meant to be a comprehensive analysis it will indicate the challenges and opportunities for researchers to develop their work in multi-disciplinary fields and activities. We believe the Subcommittee should pay close attention to this valuable document.

The emphasis on multidisciplinary activity is also reflected in the proposed FY 1988 NSF budget. The inclusion of the social and behavioral sciences in the Foundation's proposal for science and technology centers is appropriate. The proposed National Geographic Information and Analysis Center (NGIAC) will provide greater access to the products of digital remote sensing, geographic information systems, computer cartography, and computer graphics, which will form the basis for major advances in geographical analysis, spatial statistics and expert systems. The enhanced information portrayal and decision making capacities resulting from such theoretical advances will enable society more effectively to resolve the complex environmental and social issues the nation faces now and in the future. This center will involve expertise in disciplines including: geography, information science, computer graphics, political science, remote sensing, risk analysis and many others. Commercial vendors, government agencies, and research universities will share in the services that will be provided by the NGIAC.

The Decision, Risk, and Management Science Program (DRMS) is also strengthening its efforts to encourage collaborative interdisciplinary research across the decision sciences. It too is moving to accept multi-year, multi-investigator proposals for programs of research integrating research strategies and disciplinary perspectives. Three broad problem areas are suggested for exploration: 1) risk perception, communication and management; 2) group decision making; and 3) artificial intelligence approaches to problem structuring and model building for decision support. Here too the number of disciplines involved is large: from artificial intelligence and expert systems to political science, psychology and sociology, to organization design and general systems theory.

In the behavioral sciences a major initiative in the neurobiology of learning and memory will also include increased support for multidisciplinary research teams, and the establishment of a small number of multidisciplinary research and resource centers. Greater elucidation of the neural structures and processes which underlie the phenomena of learning, memory and information utilization will be the goal of this research.

These three initiatives in geography, decision, risk and management science, and psychobiology are significant indications from NSF that the social and behavioral sciences are an important part of the Foundation's agenda for economic competitiveness. Full support of the NSF's budget request will allow these important research initiatives to go forward.

Concern has been raised in many places about NSF's move to encourage the development of science and technology centers, often perceived at the expense of individual investigator initiated research. COSSA is concerned as well. For many of the social and behavioral science disciplines, the individual investigator remains the key to significant basic scientific research. Yet we can agree with Dr. Harold Shapiro, President of the University of Michigan, who told your Subcommittee that NSF support of centers "is -- at the current time -- an appropriate strategy to pursue." We also agree with his comment that the "rate of expansion of NSF funding for research centers should be cautious, retain its flexibility, and be the subject of ongoing evaluation." The Subcommittee should keep a wary eye on this situation since the long term effects of support for such centers is at the present unknown.

This would be one of the reasons we would continue to support an ongoing role for the authorization committees in their relationship with NSF. Congressional oversight through the authorization process remains an important check on the agencies of the executive branch. In this year when we celebrate the bicentennial of the Constitution, checks and balances should be reinforced. The Subcommittee should act with caution in evaluating the proposal to move to a five-year authorization for the Foundation.

There are other initiatives for the social and behavioral sciences in the proposed FY 1988 budget that COSSA believes further enhances the necessity to support the proposed increase for NSF. Proposed funding for methodological and research resource development in anthropology will include new emphasis on improving ethnographic research methods and on cross cultural research in this discipline. Analysis of regional databases will provide archaeologists with greater research opportunities.

In political science and economics, increased support for postdoctoral students in political economy will allow for greater study of international economic competitiveness, international trade, and the economic consequences of public sector growth. Continuing support for the three national social science databases -- the Panel Study of Income Dynamics, the General Social Survey, and the National Election Studies -- remains important providing the data necessary to evaluate the nation's economic, social and political progress. Data collection efforts on Supreme Court decision making should provide students and observers of the court with an important new and comprehensive source of information.

The 16% increase proposed for the Science and Engineering Education Directorate represents a further step in the reinvigoration of that directorate. The commitment of the Foundation to establish a coordinator of undergraduate education is an excellent idea. We also agree with NSF that providing resources for undergraduate education within the disciplines allows for the best integration of research and training for undergraduate social and behavioral scientists. We also applaud the enhanced support for graduate students through increased numbers of fellows and increased stipends that will somewhat mitigate the impact of the Tax Reform Act of 1986.

In the past we have regaled the Subcommittee with lists of significant research accomplishments by social and behavioral science researchers. You have demonstrated time and again your belief that these accomplishments are important to the scientific enterprise within the United States. We ask you to continue that support in the future by giving NSF its full FY 1988 request.

Thank you this opportunity to present our views.

Consortium of Social Science Associations

Members

- American Anthropological Association
- American Economic Association
- American Historical Association
- American Political Science Association
- American Psychological Association
- American Sociological Association
- American Statistical Association
- Association of American Geographers
- Association of American Law Schools
- Linguistic Society of America

Affiliates

- American Association for Public Opinion Research
- American Educational Research Association
- American Evaluation Association
- American Society of Criminology
- Association for Asian Studies
- Association for the Social Sciences in Health
- Eastern Sociological Society
- Economic History Association
- Gerontological Society of America
- History of Science Society
- International Studies Association
- Law and Society Association
- Midwest Sociological Society
- National Council on Family Relations
- National Council for the Social Studies
- North Central Sociological Association
- Northeastern Anthropological Association
- Operations Research Society of America
- Population Association of America
- Regional Science Association
- Rural Sociological Society
- Social Science History Association
- Society for the History of Technology
- Society for Research in Child Development
- Society for the Scientific Study of Religion
- Southern Sociological Society
- Southwestern Social Science Association
- Speech Communication Association
- The Institute of Management Sciences

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- Columbia University
- Cornell Institute for Social and Economic Research
- Cornell University
- Florida State University
- Harvard University
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- Ohio State University
- University of Pennsylvania
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- University of Pittsburgh
- Princeton University
- Rutgers University
- Social Science Research Council
- University of Southern California
- Stanford University
- State University of New York at Stony Brook
- University of Tennessee, Knoxville
- Texas A & M University
- Tulane University
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- University of Wisconsin, Madison
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AAES

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April 3, 1987

The Honorable Doug Walgren
Chairman
Subcommittee on Science, Research
and Technology
Committee on Science, Space, and
Technology
U.S. House of Representatives
2319 Rayburn House Office Building
Washington, DC 20515

Dear Mr. Chairman:

I am pleased to present this statement on behalf of the American Association of Engineering Societies (AAES) regarding the engineering-related activities in the FY 1988 budget of the National Science Foundation. AAES member societies represent more than 500,000 engineers in industry, academia and government; attached to our overall statement is a list of participating societies, as well as specific statements of five of these societies on the NSF budget.

The economic health and vitality of the United States, especially in areas of international competitiveness, is a major national priority of this decade. Historically, technological breakthroughs have been a key factor in increasing U.S. economic competitiveness and raising the standard of living. The recent decline in our economic competitiveness and quality of life is not only of great concern but also points to the need for refocused attention on our technological research and education programs. A significant increase in the resources directed toward engineering research and education will contribute directly to technological development and economic growth at home, as well as U.S. competitiveness abroad.

Engineering is the bridge from basic scientific research to useful applications that can be developed and commercialized by our nation's industries. To compete successfully against other industrial nations we must invest in basic generic engineering research to provide the infrastructure and talent that will allow the nation to move innovative ideas rapidly into the marketplace. Experience over the past decade has clearly shown that a major reason for the success of our international competitiveness can be directly tied to the ability to move basic scientific findings rapidly into commercial applications. Substantial increases in funding for the NSF Engineering Directorate can bring about fundamental changes in the pace of our technological development, increasing our ability to compete and substantially improving our creativity through basic, cross-disciplinary and interdisciplinary research.

We strongly support the Foundation's proposed 23 percent increase in the Computer and Information Science and Engineering (CISE) Directorate budget, and applaud NSF's two-pronged initiative to support both research into the fundamental understanding of computer and information science and engineering, as well as the expansion of participation in and the availability of advanced computing systems.

Continued support for NSF precollege mathematics and science programs is vital to the health of engineering research and higher education. Additionally, expansion of graduate programs at NSF forms another key link in the system. Creation of 200 additional graduate fellowships and 200 new Presidential Young Investigator awards, along with expansion of engineering initiation awards for young researchers, are the types of incentives that can help keep promising young graduate students in academe so they can become future faculty.

Of special significance to the engineering community is the Foundation's proposed initiative in undergraduate education, which is designed to improve undergraduate engineering curricula and faculty development, as well as expand educational instrumentation and undergraduate research programs. Since the 1970's, undergraduate education has barely been addressed at the Foundation; it is important that new undergraduate programs be developed to reverse this unhealthy situation.

We commend and share the Administration's commitment to substantially increase the NSF budget over five years. Historically, technological breakthroughs have been a key factor in increasing U.S. economic competitiveness and raising the standard of living. NSF's continued growth in research and education activities will contribute significantly to technological development and economic growth at home, and U.S. competitiveness abroad. Given the widespread support in Congress for improving U.S. competitiveness, the NSF budget should be viewed as investment in talent and in our future. This $1.9 billion request, including a $42 million increase in funding for the Engineering Directorate, though a small fraction of the Federal Government's $1 trillion budget, is a big cog in the basic research and educational activities which will ultimately fuel the economic engine of the United States. Indeed, NSF support plays a major role in the Federal funding of engineering research. To assure our future position in an ever increasing technologically competitive world, substantial investments will need to be made in engineering research and education. This year's initiative is a good start in revitalizing our technological capability.

I am pleased to have this opportunity to present the views of AAES and respectfully request that this statement and attachments be included in the Subcommittee's written record of hearings on the NSF FY 88 authorization. Thank you.

Sincerely,

Richard W. Karn

Richard W. Karn
Chairman
Board of Governors

Attachments

List of Attachments

Attachment A	Lists of AAES Societies
Attachment B	Statement of the Institute of Electrical & Electronics Engineers
Attachment C	Statement of the American Society of Mechanical Engineers
Attachment D	Statement of the American Society of Civil Engineers
Attachment E	Statement of the American Society for Engineering Education (Engineering Education Task Force)

ATTACHMENT A

List of AAES Societies

Member Societies

- Institute of Electrical & Electronics Engineers
- American Society of Mechanical Engineers
- American Society of Civil Engineers
- American Institute of Chemical Engineers
- American Institute of Mining, Metallurgical & Petroleum Engineers
- Institute of Industrial Engineers
- American Nuclear Society
- American Society for Engineering Education
- American Institute of Plant Engineers
- Society of Women Engineers
- Society of Fire Protection Engineers
- National Institute of Ceramic Engineers
- American Indian Science & Engineering Society

Associate Societies

- Tau Beta Pi Association
- Illuminating Engineering Society of North America
- American Council of Independent Laboratories
- National Association of Corrosion Engineers
- Federation of Materials Societies
- National Action Council for Minorities in Engineering

Regional Societies

- Western Society of Engineers
- Engineering Society of Detroit
- Engieering Societies of New England

ATTACHMENT B

IEEE
WASHINGTON OFFICE
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Statement of the

Institute of Electrical and Electronics Engineers

Member, American Association of Engineering Societies

on the

National Science Foundation

Fiscal Year 1988 Budget Request

April 1987

It is a pleasure to submit the views of the Institute of Electrical and Electronics Engineers (IEEE) on the proposed budget for the National Science Foundation (NSF), for fiscal year 1988. The IEEE is the world's largest technical professional society, with some 229,000 members in the United States alone. Our membership consists primarily of engineers and scientists in the electrical and computer disciplines, so we have a very great interest in the programs of the NSF.

Administration Proposals

Although this is necessarily a time of austere funding for Federal programs, we believe that the NSF's budget represents the "seedcorn" from which the U.S. economy can grow, by advancing our national strengths in science and technology. Thus we feel that the Administration is fully justified in proposing $205 million for Computer Science and Engineering, an increase of 23% as part of the overall plan to double the NSF budget in a five-year period. We see these requests as recognition of the key role played by computer and electrical/electronic technologies, now and in the future, in the health of the U.S. economy and our competitive posture internationally.

We fully concur with the proposal to broaden the earlier NSF initiatives on Engineering Research Centers to include Science and Technology Centers, particularly in Computer and Information Sciences and in Material Sciences and Engineering. The proposed new research programs in materials processes and interfaces, cognitive science and architecture, large scale systems engineering, and supercomputer applications are excellent choices as areas that have great potential impact on the future productivity and competitiveness of the nation.

As we have expressed in previous testimony, we recommend an approach which balances support for such centers with support for individual investigators in disciplinary programs, and thus, also balances support for basic and applied research. Thus we also strongly support the proposal to increase the average grant size to individual investigators, largely to correct the decline in real dollars for support of graduate students during the last ten years, and the equally important proposal to increase substantially the funding of Engineering Research Centers, so as to permit these exemplary units to function as originally envisioned. We would like to see further attention paid in future years to basic research in areas, such as telecommunications, which have not received significant increases to date.

IEEE Recommendations: Funding for Small Groups

With respect to the two general styles for supporting research activities, through centers on the one hand and individual investigators on the other, we recommend that a third approach between these two extremes should also be employed by the NSF. Because of the magnitude of funding necessary for research centers, very few can be funded. On the other hand, there are many engineering schools of small to medium size across the country, which taken together contribute a large fraction of the total number of engineering graduates in the United States each year. There is an urgent need to harness this important national resource, if we are to maximize U.S. industrial competitiveness. It is not feasible to operate centers at most of these schools, although many of them have first-class faculty investigators. We suggest that the NSF consider the possibility of initiating a program to support research teams which would not necessarily be either large or cross-disciplinary. Although such teams could, in principle, be supported through either the centers program or the disciplinary programs, it is in fact extremely difficult to compare small group efforts with the other categories. The review process for either of the existing categories tends to eliminate efforts involving three to five investigators. They are clearly too small to qualify as centers, and Disciplinary

Program Managers tend to break small team proposals into parts for separate review, which eliminates the synergism available through group efforts.

We would also like to point out that shorter-term, goal oriented research would be one particularly fruitful way of applying such smaller group grants, which could maximize their beneficial impact on productivity in U.S. science and technology. A great deal has been said and written recently about the relatively short-term focus of U.S. industry, which contrasts sharply with the long-term focus of academia. we observe that scientists and engineers from these two critical resource groups in our country are frequently most productive when working together, sharing a focus that is long enough for the results to be competitive internationally, but short enough to give a high likelihood of productive results. Government has had the wisdom to sponsor some such efforts. The NSF Centers are an example, on a larger scale; work sponsored by the Defense Advanced Research Projects Agency (DARPA) is another. DARPA sponsors a full range of team sizes, and in many cases insists on cooperative university-industry efforts in order to bring together the best of theory and practice.

We would like to encourage the NSF to provide grants to small teams of academics, including some for the purpose of working cooperatively with industry. We believe that engineering faculty members would particularly benefit from the practical experience gained in such work. At the same time a much-needed influence would be applied to U.S. industries, drawing them toward products and manufacturing methods more advanced than their current short planning horizon allows. This approach is consistent with the forward-looking management of research funding which we associate with the NSF, and hope to see it implemented under an expanding budget for the Foundation.

ATTACHMENT C

The American Society of
Mechanical Engineers

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Statement of the
Task Force on the National Science Foundation
# of the
American Society of Mechanical Engineers
Member, American Association of Engineering Societies
on the
National Science Foundation
Fiscal Year 1988 Budget Request

April 1987

We appreciate the opportunity to submit our views on the proposed fiscal year 1988 budget of the National Science Foundation. The American Society of Mechanical Engineers (ASME) is an educational, scientific, and charitable society founded over one hundred years ago. Membership in ASME exceeds 114,000 professionals in mechanical engineering. This statement was prepared by a task force of the Council on Education of the American Society of Mechanical Engineers. It represents the considered judgement of the task force, a group of experts in the field, rather than an official position of ASME.

ASME continues its vital interest in the successful implementation of the full range of NSF programs. These comments, however, focus primarily on those aspects of the budget request affecting the contributions of engineering research to national goals.

The task force endorses the Administration's plan to double the NSF budget over the next five years. These proposed increases will help NSF balance its support for programs that foster economic vitality with those that insure the long-term health of basic research. This increased level of support can make a substantial contribution to the nation's economic well-being and national security by insuring continued U.S. pre-eminence in the world-wide market place. We are especially pleased with the Foundation's long-term commitment to ensure stability of basic research programs. We are also pleased with the continued efforts to restore support for science and engineering education which was drastically curtailed in the 1982-83 period. However, we strongly urge further strengthening of NSF basic research programs in engineering.

OVERVIEW: NSF ENGINEERING BUDGET

The FY 1988 budget request for the NSF Engineering Directorate is $205 million. This is an increase of $42 million or 25.7 percent over the current FY 1987 plan of $163 million. These proposed increases and the plan to double the NSF engineering budget within the next five years are admirable in the face of the efforts to reduce the deficit and balance the budget. They demonstrate the Administration's commitment to basic engineering research. What justifies these increases is the key role that engineering research plays in improving the quality of life and in the ability of U.S. industry to compete effectively in international markets. Engineering research is a critical component of economic competitiveness.

The U.S. has clearly lost ground in economic competitiveness. A factor contributing to this was our neglect of engineering research during the 1970's. The U.S. is now fourth among industrialized countries behind Japan, West Germany, and France - in the fraction of gross national product invested in civilian research and development. This a further justification for increasing the NSF engineering budget in FY 1988.

In FY 1985, NSF supported a larger fraction of engineering research at universities and colleges than any other federal agency. Several engineering desciplines rely almost solely on NSF for engineering research support. In FY 1985, NSF supported 91 percent of all federally sponsored engineering research in Civil engineering and 84 percent of all federally sponsored engineering research in Chemical engineering at universities and colleges. More importantly, NSF is the only non-mission agency whose purpose is to support both basic and applied long-term engineering research across a broad spectrum of fields. The results of the research provide a basic knowledge that helps to stimulate technological innovation in the private sector, which in turn can impact U.S. competitiveness in the international marketplace.

The Engineering Division of NSF has programs in two broad areas, basic or disciplinary engineering research, and more focused or cross-disciplinary engineering research. In FY 1988, 70 percent or $29.4M of the $42M increase will be in the focused or cross-disciplinary areas of engineering research. These include the Engineering Research Centers (ERCs), an $18.5M increase or 44 percent of the total increase; the Emerging Technologies Division, a $3.7M increase or 9 percent of the total increase; the Critical Engineering Systems Division, a $3.2M increase or 7.6 percent of the total increase; and the Design, Manufacturing and Computer-Integrated Engineering Division, a $4.0M increase or 9.5 percent of the total increase.

The basic engineering programs will receive a $12.6M increase. The Chemical, Biochemical and Thermal Engineering Division is slated for an increase of $3.1M or 7 percent of the total increase; the Mechanical Structures and Materials Engineering Division, $3.6M or 8.6 percent of the total increase; and the Electrical, Communications and Systems Engineering Division, $5.9M or 14 percent of the total increase. It should be noted that even within these divisions, the largest increases are in the more focused or cross-disciplinary programs. For example, the Materials Engineering and Processing Program in the Mechanics, Structures, and Materials Engineering Division is budgeted for a $1M increase; and the Large Scale Non-Linear Systems Program in the Electrical Communications and Systems Engineering Division is budgeted for a $2.7M increase.

While it is too early to gauge all the benefits to be derived from multidisciplinary Engineering Research Centers, they have already prompted significant intellectual and financial efforts and cooperation in the academic community, as well as strong financial support from industry. We believe that many exciting projects are being developed within the ERCs which have the potential for major breakthroughs in such areas as telecommunications, robotics, biotechnology, and the development of composite materials. We believe that the current 15 authorized centers merit continued strong support, and that the number could be appropriately expanded in FY 1988 to as many as 21 centers. We, therefore, endorse the Foundation's request for an increase of $18 million in the ERC program to $48 million. We hope that the Subcommittee will give this request its fullest consideration.

In addition, we fully support the projected growth in funding levels for the cross-disciplinary programs, the Industry/University Cooperative Research Centers (IUCs) and the Presidential Young Investigator (PYI) programs. NSF resources for fundamental engineering research should continue to be managed to ensure that industry is an active partner with universities. The ERC, IUC, and PYI programs are appropriately designed to accomplish this goal. An important and potentially long lasting result is that an industrial commitment to ERCs, IUCs, or PYI encourages industry to commit a larger share of its own resources to applied research and development than might otherwise occur.

While the increases proposed address the needs of the ERCs, the emerging engineering technologies, the critical engineering systems and other more focused or cross-disciplinary programs, there is a need to establish a balance between these programs and the more traditional programs that provide funding of investigators working individually in one of the classical engineering disciplines. The need for this balance is clearly apparent in years of budget cuts. Because the increases in these traditional programs have been less than in the more cross-disciplinary programs, an across the board budget cut has a greater effect.

One way to alleviate the problem would be for the NSF Engineering Directorate to establish more formal mechanisms of interaction and cooperation between the disciplinary and cross-disciplinary programs.

We now move to comments on the specific engineering divisions at NSF.

CHEMICAL, BIOCHEMICAL, AND THERMAL ENGINEERING DIVISION

One continuing objective of the NSF in FY 1988 is "to strengthen multidisciplinary research and training in engineering at universities." In the formation of this Division as part of the NSF re-organization, new and improved symbiotic relationships were created between programs related to chemical, biochemical, and thermal processes. This is particularly true in the Division's Thermal Systems and Engineering Program, which is a merger of previous programs in heat transfer, thermal systems, and combustion. This progress continues and the 1988 budget request continues support of this initiative.

Of the five programs in the Division, the Thermal Systems and Engineering Program remains the largest and most central to mechanical engineering education and practice. Approximately 35 percent of the 3,800 mechanical engineering faculty members in U.S. universities teach and do research in the thermal systems area. Fundamental research in thermal systems impacts on virtually every industry and product - e.g., manufacturing, transportation, health care and human rehabilitation, defense systems, and the supply of energy, materials, and food. The recent Space Shuttle disaster was assessed as a thermal systems problem. The U.S. is rapidly losing still another basic industry - i.e., aluminum production - because insufficient understanding exists on how to solve the thermal systems problems - i.e., how to reduce energy required to produce the aluminum so that the total production cost is competitive with that of competitors in other countries.

Increased understanding of the behavior and operating limits of industrial thermal processes, equipment, and components relates significantly to long-term restoration of the competitive position of U.S. industry to world markets. Clearly, the requested $8.88 million for the thermal systems portion of this program in FY 1988 is very modest considering the pervasiveness of thermal processes. We also note that while this is above the 1987 current plan, it is below the 1987 budget request. This would be a major concern since heat transfer, which is part of thermal systems program, is key to most of the emerging engineering technologies. For instance, the development of techniques for very rapid cooling, more rapid than ever before believed possible in heavy manufacturing, has been the key for a novel process of connecting rod manufacture recently announced by General Motors. This process is widely considered a major breakthrough in automotive manufacturing. At the other end of the scale, heat transfer is the key to several highly desirable advances in the development of electronic devices.

It is also important to recall that increased progress in this sub-field will contribute to a reduction in energy consumption. This remains a national priority in spite of recent, and surely temporary, relief in energy pressures.

We applaud the indicated new intiatives in thermal processing; the search for new catalysts to replace the platinum group metals; the emphasis on aerosol technologies; and the emphasis on neglected areas of materials science in engineering applications. It is, however, unfortunate to note the required budget reductions in CBTE for 1987, and their subsequent impact on continuing research in these vital areas.

MECHANICS, STRUCTURES, AND MATERIALS ENGINEERING DIVISION

This division supports fundamental research on the behavior, response, and failure of materials, structures, machines, and their components. The objective is to advance the engineering methodology underlying the mechanical, structural, materials processing, manufacturing, and natural resource management and control technologies.

We are pleased to see the proposed $1 million increase in the materials engineering and processing program. This a priority for ASME. The proposed 14.5 percent increase for this division is essential to maintain the division activities at acceptable levels.

The programs within this division have the potential to have a major impact on the economic competitiveness of the U.S. For example, the Dynamic Systems and Control program can contribute substantially to the long-term restoration of America's world leadership position in the production of machines, processes, structures, vehicles, and other devices. The NSF can be a catalyst in supporting much needed fundamental and generic research in the vital area of dynamic systems and control of mechanical systems. Yet, the level of funding projected for this program in FY 1988 is considerably less than required, considering its broad scope, integrative nature and relevance to the critical mechanical and manufacturing industries of the nation. The funding level for this program should be increased at a significantly higher rate over the next several years than has been projected for FY 1988. Otherwise, the urgently needed development of new knowledge and the expansion of the manpower base in the critical field cannot be achieved.

The budget levels for the other programs in this division should also be given priority for further increases. Given that each program has to support a specified number of Presidental Young Investigator Awards, and that the Fluid Dynamics and Hydraulics program supports the largest number of PYIs in the directorate, the funds available for the support of research in some of the programs in this division have not been substantially increasing. Considering the increase in costs of supporting research, it is possible that, if these funding trends continue, the number of investigators and graduate students supported by these programs could be half of their 1984 levels by 1990.

ELECTRICAL, COMMUNICATIONS, AND SYSTEMS ENGINEERING DIVISION

This division supports research to develop an engineering knowledge base for the analysis, synthesis, design, and fabrication of materials, components, devices, systems, and phenomena that involve electrical, electronic, electromechanical, or optical technologies. In addition, the Systems/Theory and Operations Research and Large Scale Non-Linear Systems programs are responsible for developing generic principles and methodologies that support the full range of engineering systems.

We are pleased to see proposed substantial increases for some of the programs in this division, particularly for the Solid State and Micro-structures program (16.9 percent), the Instrumentation, Sensing and Measurement program (27.3 percent), and the newly formed Large Scale Non-Linear Systems program (117.4 percent).

Given the budget cuts of previous years, the other programs in this division, even with the proposed 10 percent increase, would be operating at FY 1986 levels.

There is a need to give priority to restoring these programs to acceptable levels.

DESIGN, MANUFACTURING, AND COMPUTER-INTEGRATED ENGINEERING DIVISION

We are pleased to see the proposed increased support of 28.4 percent, from $14 to $18 million for manufacturing and related research, which is a major area of emphasis in the ASME technical programs. Unlike the traditional "mature" mechanical engineering related disciplines of thermodynamics, fluid mechanics, heat transfer, and solid mechanics, the disciplines encompassed by design, manufacturing and computer engineering are only now emerging and being codified. They lack a strong science base, but such a base appears feasible. These "emerging disciplines" provide an integrating framework for the continued significance of the mature mechanical engineering disciplines. Moreover, these emerging disciplines are of vital importance to the international competitive strength of the U.S.

These emerging disciplines have been neglected within the universities so long that major new initiatives are needed to revitalize the related instruction and research programs, and to rebuild the human resource base needed. It is interesting that some university faculty members who formerly worked in the traditional engineering science areas are now migrating to these emerging disciplines. This shift is fortunate, since there will follow a better understanding of the need to focus on fundamental research issues. There appears to be a clear dichotomy between the fundamental and generic research needs that should and will be addressed through the Division's programs, and those that should be addressed by industry and other federal agencies.

In a study of "Research Needs in Mechanical Systems" conducted for the NSF by the ASME, four basic disciplines were identified as being of critical importance to the economic health of the nation: dynamic systems and control, design methodology and interactive computer graphics, machine dynamics, and tribology. In addition, a principal outcome of the study was the recognition that developing national capability in computer-integrated systems and design and implementation is the single most important issue in the field of mechanical systems. On this last point, it is concluded that a major national initiative is needed in computer integration: in design, manufacturing and operations; in intelligent products; in the computer-human interface; and in the processes of education and professional practice. It was recognized that this need goes far beyond the field of mechanical systems and is, in fact, a major national need in all engineering fields. The programs in the new division are structured to address this national need.

The ASME study of Research Needs in Mechanical Systems, and several other NSF supported studies, have had a profound influence on the new structure and mission of the Engineering Directorate. The major recommendations of the ASME study have been fully incorporated. The NSF has been responsive to input from the research community, and quite perceptive of their role in focusing on national priorities. We have recently proposed a similar study of research needs in manufacturing to assist NSF and the Department of Defense in identifying research imperatives with the greatest potential for advancing U.S. technological leadership.

The emergence of the fields of artificial intelligence and expert systems promises to provide the stimulus for greater understanding of design as a process, as well as a guide for development of fundamental axioms for design. The continued development of the tools of geometric modeling, and more generally interactive computer graphics, can potentially revolutionize the way design is done, and the way in which design results are transferred into quality and competitive manufactured products.

The programs in this division support research aimed at developing the base of scientific knowledge needed for rapid advances in design and manufacturing. Without such advances, the international competitiveness of U.S. industry will continue to erode, and more basic industries will move offshore.

EMERGING ENGINEERING TECHNOLOGIES DIVISION

The purpose of this division is to support those technological areas that show promise for enhancing, over the long-term, the national economy, employment base, and security, and for which the Nation's universities do not yet have an adequate research and human resources base. The proposed NSF budget incorporates a 23.9 percent increase in FY 1988 funding compared to the current plan for FY 1987. Particularly impressive are the increases in Biotechnology ($1 million) and the establishment of a new program in Neuro-engineering at a funding level of $2 million. The programs in Biotechnology, Bioengineering, and Neuroengineering represent in many ways a new frontier and an opportunity for the United States to maintain a position of leadership in an area that may affect very profoundly our future technological strength. The Computational engineering program of this division is an area where foreign competition is becoming stronger; the importance of this field is paramount not only from the point of view of overall technological leadership, but also from the points of view of productivity and of national defense.

We applaud the approach taken in this division, namely to add or subtract emerging areas as the need is established. We believe that it is proper for NSF to take a position of leadership in shaping the research direction of the future.

CRITICAL ENGINEERING SYSTEMS

This is a new division with most of the programs formerly in the old Emerging and Critical Engineering division. This division deals with research areas that involve large scale systems in such areas as earthquake hazard mitigation, environmental engineering, systems engineering for large structures, and material and man-made hazard mitigation.

This division has a proposed increase of 12 percent. Given that the actual FY 1987 budget is an 8.2 percent decrease over FY 1986, the proposed increase represents a modest increase for FY 1988.

CROSS DISCIPLINARY RESEARCH

This activity has gained tremendously in importance with the initiation of the NSF Engineering Research Center (ERC) program. The key role that such centers can play in fostering cross-disciplinary research was clearly defined in the report from the National Academy of Engineering that originally proposed this new approach. Since the inception of this program, 312 ERC proposals have been received from 60 percent of the graduate degree granting engineering schools, showing the strong academic interest in these activities. Even more significant is the partnership that the ERCs have with industry and state governments. These sectors have joined in support of the concept to more than double NSF's annual contribution. This strong support indicates the widely held belief that these centers will contribute significantly to American industrial productivity and international competitiveness.

ASME is firmly committed to encouraging cross-disciplinary research that provides for the involvement of industry, universities, and government. Our new Institute for Innovative Excavation Equipment and Systems, for example, will involve personnel from electrical, civil, mining, computer engineering, mechanical, industrial, and other engineering departments from universities all across the country. Researchers from these departments will work together with personnel from industrial and government laboratories on projects of mutual interest.

We endorse the proposed FY 1988 increase in the Engineering Research Center program of $18 million.

The remaining activity under the Cross-Disciplinary heading, the Industry/University Research Centers, is projected to increase from $0.5 million to $3.5 million.

CONCLUSIONS AND RECOMMENDATIONS

We support the major outlines of the FY 1988 budget for the Engineering Directorate and praise the Foundation's commitment to developing and sustaining a high level of federal support for both engineering research and education. Given the impact that engineering can have on U.S. economic competitiveness and the importance of NSF to many areas of basic and focused engineering research, we feel that it is indeed essential that Congress at least double the Foundation's budget over the next five years.

These budget increases will help NSF balance its support for programs that foster economic vitality with those that ensure the long-term health of basic engineering research. In particular, the five year plan to more than double the Engineering budget to $500 million by FY 1992 will provide the necessary funds to restore a proper balance between basic and focused engineering research.

We should point out that as ambitious as these budget increases may seem, they may not be enough. There is much catching up to do in areas that have been neglected for too long. Further, it must be recognized that the five year plan will be difficult to achieve if the Congress does not take the first step toward that goal by approving a significant increase for the FY 1988 budget of the Foundation.

It is our hope that the Subcommittee will see the budget as an important investment in the nation's economic and industrial future, the rewards of which the nation will reap many times over.

Task Force on the
National Science Foundation
FY 1988 Budget

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ATTACHMENT D

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Statement of the
Engineering Education & Research Policy Committee
# of the
American Society of Civil Engineers
Member, American Association of Engineering Societies
on the
National Science Foundation
Fiscal Year 1988 Budget Request

April 1987

Civil engineers make the difference
They build the quality of life

The Engineering Education and Research Policy Committee of the American Society of Civil Engineers (ASCE), urges your support for the Administration's $1.9 billion 1988 budget request for the National Science Foundation (NSF). Understandably, concerns about the federal budget deficit may call into question NSF's proposed $270 million (17%) increase, however, the nation's commitment to enhancing U.S. competitiveness underscores the importance of preserving this budget increase.

Engineering Directorate funding would rise by $42 million (or 26%) to a level of $205 million. ASCE is particularly encouraged by increased support for Mechanics, Structures, and Materials Engineering of $3.6 million (14%) to a level of $28.5 million, and by increased funding for Critical Engineering Systems of $3.2 million (13%) to a total of $27.7 million. A substantial $18 million (56%) increase for cross-disciplinary Engineering Research Centers (ERCs) would raise the number of ERCs from 15 to 21. The ERCs expedite the transfer of research results from the lab to America's application in the global market place.

Computer and Information Science and Engineering would be boosted by $26 million (23%) to a level of $143 million. In addition, NSF's important commitment to Science and Engineering Education would rise 16 percent, to a level of $115 million. This funding will support important and expanded education efforts at the precollege, undergraduate, and graduate levels.

We commend and share the Administration's commitment to substantially increase the NSF budget over five years. Historically, technological breakthroughs have been a key factor in increasing U.S. economic competitiveness and raising the standard of living. NSF's growth in research and education activities will contribute significantly to technological development and economic growth at home, and U.S. competitiveness abroad. Given the widespread support in Congress for improving U.S. competitiveness the NSF budget should be viewed as investment in talent, and our future. This $1.9 billion budget request, though a small fraction of the Federal Government's $1 trillion budget, is a big cog in the basic research and educational activities which will ultimately fuel the economic engine of the United States. NSF support, indeed, plays a major role in the Federal funding of civil engineering research.

During the 1970's the United States lost ground in the area of economic competitiveness to several industrialized countries. This FY 1988 budget, as part of the five year plan to increase the Engineering Doctorate budget to $500 million by FY 1992, will help us to begin making up for lost ground. ASCE strongly supports the fiscal 1988 budget request for NSF and urges your approval of it.

ATTACHMENT E

Statement of the

Engineering Education Task Force

on the

National Science Foundation

Fiscal Year 1988 Budget Request

April 1987

We appreciate this opportunity to share our views on the National Science Foundation budget for Fiscal Year 1988. This statement is being submitted for the record by the Engineering Education Task Force, a multi-society group working together to address major issues in engineering research and education. Member organizations are the American Society for Engineering Education (ASEE) including its Engineering Deans Council, the National Society of Professional Engineers (NSPE), and the National Association of State Universities and Land Grant Colleges (NASULGC).

ASEE is a membership society of more than 10,000 faculty, as well as schools of engineering and engineering-oriented industries. NSPE is a professional society representing 75,000 professional engineers in industry, private practice, government and education. NASULGC is a higher education association whose member colleges and universities educate more than two million of the nation's students.

The Engineering Education Task Force strongly endorses the proposed FY 1988 budget for the National Science Foundation (NSF). We believe the substantial increases proposed for engineering research and education recognize the vital role of the nation's engineering enterprise in strengthening U.S. economic competitiveness and the quality of life. It is the research achievements and education of young engineers and scientists today that will lead the nation into the high technology future of the 21st century. Our comments will focus on the education programs within the Foundation.

NSF Education Programs

Continued support for NSF precollege mathematics and science programs is important to the health of engineering and scientific research and education. Highly motivated, well-prepared students must come out of the high school pipeline or the nation will face a serious shortage of the engineering workforce necessary for the increasing needs of government, industry and academe. NSF precollege programs in recent years have helped spur a nationwide effort to improve precollege mathematics and science. They can inspire such efforts as the MATHCOUNTS program sponsored by NSPE in which seventh and eighth grade students receive coaching and participate in mathematics competitions, and the Junior Engineering Technical Society (JETS) sponsored jointly by ASEE and NSPE.

Expansion of graduate programs at NSF forms another key link in strengthening the engineering education system. Expanding the number of graduate fellowships, Presidential Young Investigator (PYI) awards, and engineering research initiation awards will help more institutions attract, keep and develop promising young engineers as graduate students and faculty members. One of the most serious problems facing schools of engineering today is the shortage of faculty: a 1985 ASEE survey showed an 8.8 percent vacancy rate in funded engineering faculty positions. The figure rises to an alarming 19 percent if one considers restoring the faculty-student ratios of the mid-1960's. There are several reasons for the faculty shortage -- including higher salaries and better research facilities in industry -- but prestigious NSF fellowships and research opportunities offer important incentives for the brightest students to consider academic engineering careers.

The Undergraduate Education Initiative

Of special significance to the engineering community is the Foundation's proposed initiative in undergraduate education. Over the past several years, NSF has maintained strong graduate education programs and since 1983, has considerably upgraded its precollege activities. But since the 1970's, undergraduate education -- the vital bridge between high school and graduate study -- has been sorely neglected at the Foundation. This new undergraduate initiative will begin to redress that unhealthy situation.

Unlike the scientific disciplines where the principal point of entry into the professions is the doctoral degree, more than two-thirds of the nation's new engineers complete their formal education with the baccalaureate degree. This makes it particularly critical that undergraduate engineering education be first-rate; most engineers do not go to graduate school to learn the technological tools and processes of their profession.

Serious Problem Areas

Partly because of its own success and because of increasing government and industry demand for engineers, the engineering education system is under severe strain. Engineering enrollments have doubled over the past 10 years at the same time that engineering schools have been experiencing serious fiscal constraints. In combination with other factors, this strain on resources has led to:

--- serious overcrowding of classrooms with resulting faculty overload, loss of morale and "burnout",

--- a severe shortage of engineering faculty, particularly in such areas as electrical and computer engineering. The ASEE 1985 survey showed an 8.8 percent vacancy rate in funded engineering faculty positions, up from 8.5 percent in 1983,

--- inability to update curricula to reflect rapidly changing technologies and engineering practice,

--- deterioration of laboratory experiences because of obsolete equipment and facilities, along with the rapid pace of change in instrumentation,

--- continuing low numbers of U.S. engineering students going on to graduate study and attainment of the PhD. The ASEE 1985 survey showed that only 59 percent of engineering graduate students were U.S. citizens; the remaining slots were filled by non-citizens,

--- reduced rate of success for engineering schools in attaining a full six year accreditation rating.

These problem areas have been well-documented in such recent reports as the National Science Board's Undergraduate Science, Mathematics and Engineering Education (NSB 86-100) and ASEE's Quality of Engineering Education.

The Role of NSF

NSF cannot be expected to address these problems singlehandedly nor to remedy the situation overnight. But what the Foundation can do is what it does best: demonstrate federal leadership in an area of national importance, serve as a catalyst for the best minds in academia to turn their attention to researching and developing solutions to the problems, and leverage resources from industry, state and local governments and academic institutions in a broadly-based, synergistic effort to address the challenge.

We believe NSF's proposed $68 million program for FY 1988 is an important step in this direction and we applaud the Foundation's foresight and commitment to substantially improving undergraduate engineering and science education.

What Can NSF Do?

Curricula Reexamination. By providing a nationally competitive, merit-based program of support, NSF can inspire major reexamination of engineering curricula including means of incorporating design, synthesis, computer integration and engineering systems into curricula, as well as finding innovative ways of making teaching more effective and efficient. This can include development of new computer softwares, creation of self-paced learning modules or new instructional technologies for face-to-face and learning at a distance.

Laboratory Redevelopment and Instrumentation. In recent years, the engineering laboratory experience for both undergraduate and graduate students has deteriorated. In conjunction with curricular redesign, the laboratory experience must be revitalized. Efforts are needed to find cost-effective ways of providing students with hands-on technical experience, including exposure to contemporary engineering practice and today's technologies.

Faculty Development. A wide variety of NSF-fostered activities could increase the attractiveness of faculty careers and contribute to the lifelong professional development of individual faculty members. The possibilities include new research opportunities not only in technical fields but in engineering teaching and learning, as well as expanded workshops, seminars, sabbatical leaves and faculty networking.

Undergraduate Research. Opportunities for promising undergraduates to experience first-hand the rewards and challenges of academic research could prove a major new incentive for students to continue on to graduate study and academic careers.

Summary

Through the Foundation's leadership, its role as a catalyst for activity, and its ability to leverage resources, we believe these programs will generate a nationwide effort to revitalize undergraduate science and engineering education. This, in turn, will help ensure the nation sustains the skilled, well-educated and flexible workforce necessary for it to remain competitive in the economic, industrial and national security spheres.

Once again, the Task Force urges you to fully support the FY 1988 budget request of the National Science Foundation. We believe the Foundation's research and education programs -- particularly the undergraduate education initiative -- represent a sound investment that will benefit the nation both now and in the decades to come.

PUBLIC AND SCIENTIFIC AFFAIRS BOARD
AMERICAN SOCIETY FOR MICROBIOLOGY

1913 I Street, N.W.
Washington, D.C. 20006
Telephone: (202) 822-9229

April 8, 1987

The Honorable Doug Walgren
Chairman, House Subcommittee on Science
 Research and Technology
Committee on Science, Space and Technology
2319 Rayburn House Office Bldg.
Washington, D.C. 20515

Dear Chairman Walgren:

The American Society for Microbiology (ASM) wishes to comment on the Fiscal Year (FY) 1988 budget for the National Science Foundation (NSF). The ASM is the largest single biological life science organization in the world with an active membership of about 35,000. Many of these individuals are engaged in biological research and a sizable number are recipients of grants administered by the NSF. A large number of areas are represented in their interests, including molecular genetics, biotechnology, photosynthesis, nitrogen fixation, regulation of gene expression, immunology and ecology.

Looking ahead at the future of the National Science Foundation, and planning for the role the NSF should play in supporting American science, the Administration has proposed that the budget for the NSF be doubled over the next five years. As an important first step in this direction, the Administration is proposing a 17% increase over the FY 1987 allocation for FY 1988, and looks ahead to a 14% increase for FY 1989. The ASM heartily endorses this recommendation and supports the objective of increasing our national level of commitment to the NSF in order to realize more effectively and completely the potential for excellent science in America.

A proposed increase of 17% for 1988 might at first sight seem overly generous at a time when the size of the federal budget deficit causes concern, calling for the exercise of responsible budgetary stringency. However, the NSF is one of the few government agencies responsible for generating new scientific knowledge, providing this country with the tools needed to aggressively compete with other nations in the arena of scientific discoveries and their applications in both agriculture and industry. We cannot afford to slight this important part of our national effort. The recent White House Science Council Report on the Health of U.S. Colleges and Universities concluded that today's federal investment in universities is inadequate to meet the demands for developing talent and new knowledge. The total dollar increase requested for FY 1988, $270 million, is a relatively small amount in terms of the federal budget as a whole, and is certainly a small amount when measured in terms of the invaluable returns that will be harvested in the form of increased knowledge and understanding in important areas of science. We fully concur with former House Science and Technology Committee Chairman Don Fuqua's recommendation that "Basic research, which comprises only .8% of the federal budget, could be increased substantially without reaching a point of diminishing returns."

The NSF's Biological, Behavioral and Social Sciences Directorate (BBS) supports a significant amount of the research done in the United States on basic mechanisms of cells and the molecular basis of life. It supports about 90% of the basic environmental biology research at colleges and universities. The NSF biological sciences program has contributed to a better understanding of the structure, function and regulation of genes and the use of gene transfer techniques for the potential improvement of economically important plants. The program has generated new knowledge from biochemical, cellular and physiological research in the plant sciences, specifically in the area of photosynthesis and nitrogen fixation and plant resistance to stress. Genetic engineering techniques are being developed which may lead to increased food production for the world. Studies in the utilization of biological systems and biomass conversion for the production of chemical materials promise alternate domestic sources of energy and critical materials of biological origin in the future. NSF's role in supporting fundamental research in microbiology and molecular biology is crucial to the rapid development of biotechnology which will strengthen our economy.

The following are just a few examples of significant advances that NSF support of high quality science has led to in recent years:

- a gene that codes for light production was transferred into the genetic material of a complex multicellular organism. The firefly gene promises to be a valuable rsearch tool for tracing gene expression within living systems, for learning more about plant development and for genetic engineering in plants, leading to new technology which can be used by the biotechnology industry for developing new products, e.g., pharmaceuticals and more productive, more nutritious and disease resistant crops;

- the discovery of a unique bacterium Heliobacillus mobilis that acts as a natural fertilizer, a finding which represents a giant step in the evolution of ancient life and may also be useful in modern agriculture as a living nitrogen fertilizer;

- the first automated DNA sequencing machine was developed, an instrument that will aid in finding the underlying basis of cancer and genetic diseases and accelerate basic research on how life operates at the molecular level;

- the structure of a common cold virus was determined rapidly through the use of a supercomputer, a finding which could pave the way

> for the development of vaccines for colds and
> other human ailments because it provides
> insight into how a virus works.

We wish to emphasize that individual investigator-initiated research grants play a critical role in ensuring that significant advances in scientific knowledge continue to be made. New ideas and new solutions arise largely from the efforts and creative energies of individual scientists supported by individual research grants. Continued and increased support for this essential avenue to future discoveries is needed if this country is to maintain a position of international leadership in science.

Our analysis of the budget for the NSF Biological, Behavioral and Social Sciences Directorate shows an unfortunate trend which has developed over the years at NSF. Both the proportion of proposals received that were able to be funded and the size (in buying power) of the individual awards has declined. By awarding insufficient numbers of grants, potential good science was not supported and was lost; by decreasing the buying power of the grants that were awarded, in many cases the ability to carry out a project was compromised, and as a result the project was weakened.

Recently some effort has been made to reverse this trend. However, there is still a long way to go to make the most of the opportunities we have before us. At present, some programs within BBS are able to make awards for only 10% of the proposals received, and that only by dint of economizing by paring down the budgets of many of the awarded grants. Some very fine proposals have to be turned away. In order to take full advantage of the research potential of the scientific community in this country, both the numbers and the amounts of individual research grants should be increased substantially, to even a greater extent than is specified in the Administration's proposal.

An average grant in the biological sciences funded by the NSF supports limited personnel and supplies and leaves little or no funding for the acquisition or replacement of relatively low-cost instrumentation, which is the sort of equipment that is used heavily and cannot be shared with other labs. Most research in the biological sciences is carried out with modern techniques and equipment which are more expensive than in the past. At their present level of funding, grants awarded by BBS are below the level necessary to maintain an efficient program of research and do not serve as a mechanism for replenishment of relatively low-cost pieces of equipment (under $100,000).

The BBS plans to increase the average award from $70,000, estimated for FY 1987, to a goal of $78,000 for FY 1987, a worthy objective. However, on the other side of the coin, while planning to increase the size of the awards, the proportion of proposals that will be funded has been reduced.

We believe that even now many fine proposals fail to win support; to reduce the proportion awarded even further would leave even more worthy projects without support. To start a trend in the other direction, we propose that the proportion of proposals to be funded within the subactivities of the Molecular Biosciences, Cellular Biosciences and Biotic Systems & Resources in FY 1988 be restored to the FY 1986 actual level plus a 5% increase. This action would permit funding approximately 720 additional proposals. To fund them at the FY 1988 level would require addition of approximately $63.3 million, distributed among these three subactivities. In our view, such a relatively small, targeted increment would yield disproportionately great benefits in relation to the size of the outlay.

Several initiatives have been emphasized in the plans for strengthening the NSF. Aside from the initiatives in the field of Engineering, resources are committed to be used to support Biotechnology, an area where funding has been inadequate to ensure continued US leadership. Recommendations are made to create a number of shared-user instrumentation facilities as well as a small number of sophisticated multi-disciplinary research centers.

Attention is also focussed on the need to expand and improve science education and the training of future scientists. These needs are addressed at steps extending over many stages of education, from secondary school through college, graduate school and at the postdoctoral level. We agree with the need to improve the scientific literacy of the public and the need to train well the next generation of scientists, and we support the measures that are proposed. Data from several government sources indicate a shortage of certain types of biological scientists and support predictions of greater shortages in certain fields in the near future. It is essential to train additional individuals in the biological sciences to take advantage of the current expansion of research opportunities.

Each of the worthwhile initiatives in the NSF budget proposal requires and merits budgetary support. However, in our view such financial support must be in addition to, not instead of, significantly increased support of the backbone of the nation's scientific endeavor, the individual investigator-initiated research project. While we support the concept of addressing the need for university-based multidisciplinary, multi-investigator research, we are concerned that without substantial growth in the NSF budget in the future, the proposed new science centers could absorb an increasing share of NSF resources and compete with the individual investigator initiated research grant for scarce research dollars. Therfore, we urge that a continued emphasis be placed on individual investigator initiated research grants and that increased NSF funding be obtained and used to establish multidisciplinary centers. As a part of the initiative to establish the new centers, we recommend that a mechanism be set up to monitor and evaluate their effectiveness.

The ASM asks that each of these considerations be weighed as decisions are made by the Congress regarding the authorization for support of the National Science Foundation in 1988.

The ASM appreciates the opportunity to comment on the FY 1988 budget request for NSF and stands ready to provide additional information or assist in any way possible during the budget process for NSF.

Sincerely,

Jean E. Brenchley

Jean E. Brenchley, Ph.D.
President
American Society for Microbiology

H.O. Halvorson

Harlyn O. Halvorson, Ph.D.
Chairman, Public and Scientific
Affairs Board, ASM

Monica Riley

Monica Riley, Ph.D.
Chairman, Committee on Genetic and Molecular
Microbiology, PSAB

American
Psychological
Association

STATEMENT OF

Leonard D. Goodstein, Ph.D.

Executive Director

American Psychological Association

on behalf of

THE AMERICAN PSYCHOLOGICAL ASSOCIATION

before the

UNITED STATES HOUSE OF REPRESENTATIVES

Subcommittee on Science, Research and Technology
Committee on Science, Space and Technology

on the subject of

NATIONAL SCIENCE FOUNDATION AUTHORIZATION

Fiscal Year 1988

April 10, 1987

The Honorable Doug Walgren, Chairman

1200 Seventeenth St. N.W.
Washington, D.C. 20036
(202) 955-7600

On behalf of the American Psychological Association, I am pleased to submit our views on the reauthorization of the National Science Foundation (NSF) for Fiscal Year 1988. APA represents the concerns of more than 87,000 psychologists, many of whom conduct important scientific research with the support of NSF.

In this statement we address specific areas in the Administration's proposal, which reauthorizes programs and activities and introduces new initiatives within NSF for FY 1988. We also comment on the Administration's proposed FY 1988 budget for NSF, focusing on areas of particular concern to behavioral and social scientists.

NSF FISCAL YEAR 1988 REAUTHORIZATION

APA appreciates this opportunity to strongly endorse the Administration's proposal to increase the National Science Foundation budget by 16.5 percent for FY 1988 to a total of $1.89 billion. Moreover, we applaud the President and NSF Director Erich Bloch for their foresight in proposing that the NSF budget be doubled over the next five years to $3.2 billion in FY 1992. These proposed increases signify a commitment by this Administration to invest in basic scientific research as part of this nation's goal to become more competitive internationally. Such a commitment requires a long-term investment to rebuild our scientific base and to ensure ongoing support for innovative basic scientific research. We urge Congress to support enhanced basic scientific research, which provides the requisite foundation for improving economic growth, productivity and competitiveness, and we encourage the Subcommittee to approve the resources needed to accomplish this goal.

BEHAVIORAL AND SOCIAL SCIENCES

APA commends the Administration for its proposal to increase funding for Research and Related Activities by 16 percent to $1.64 billion. Of particular interest to APA are the specific increases targeted for behavioral and social sciences research, adding $39.3

million to the Biological, Behavioral and Social Sciences (BBS) Directorate. However, funding for the Behavioral and Neural Sciences and the Social and Economic Sciences Divisions is still disproportionately below historical authorization levels. Although the total NSF budget has been significantly increased over the past few years, funding for the behavioral and social sciences programs has actually diminished in relationship to other research areas. In FY 1980, 6.1 percent of NSF's Research and Related Activities budget was allocated for behavioral and social sciences research, and by FY 1988 it had decreased to only 4.1 percent. APA recommends that Congress target at least 5 percent of the Research and Related Activities budget towards the behavioral and social sciences.

The behavioral and social sciences have a critical role to play in these efforts to revitalize the nation's economic and technological base. While our international competitors have been quick to recognize these contributions, increases in productivity that could be realized by modifying organizational structures, personnel policies and decision-making processes have too often been overlooked as critical areas for research in the United States.

While technological advances are important, behavioral and social science research can be even more important in developing new human, social and institutional approaches in revitalizing this nation's industrial base. A few examples follow:

- Basic research in the social and behavioral sciences plays a much clearer and more consequential role in american institutions and industry than is typically recognized. There is a certain irony in that the findings of this research are perceived by foreign countries to have great export value. For example, it is often suggested in our media that the current superior position occupied by the Japanese steel industry is intimately related to their development of the notion of quality control circles. These control circles rest on two major concepts: a statistically based system of quality control, and participative decision-making. The notion of participative decision-making rests very clearly on basic research in social psychology going back three or four decades.

- The management structure and processes of American industry are often based on straight-forward behavioral science research. This research includes studies of the relationship of morale and employee satisfaction to productivity, the effects of employee participation in decision-making on productivity, the nature of resistance to change of management practices, employee profit-sharing plans, and the relationship of styles of leadership to group productivity.

- A global study on the impact of organized programs designed to increase employee productivity in the workplace found that the average worker's productivity did, in fact, increase significantly (Guzzo, Jette and Katzell, Personnel Psychology, 1985, Sum. Vol., 38(2), 275-291). This study analyzed the findings of 100 separate studies covering 11 types of psychologically-based organizational interventions. Not all interventions were equally effective. The most powerful strategies, it was found, were in the areas of employee training and goal setting. Suprisingly, supplying employees with increased financial incentives did not reliably lead to increased productivity. The effects of worker incentive programs varied widely the study found, sounding a warning to those who depend solely on increasing compensation to boost productivity.

- The field of psychology has made great strides in understanding how to maxmize productivity, through job-person matching, test validation, and utility analysis. The field is now addressing quality in one's work life, retraining for technological change, and the development of work values and attitudes. Related to these areas of "cutting-edge" psychology are new integrations which are occurring between experimental psychology and human factors research in studying and making recommendations about lighting conditions on roadways, risk-taking under conditions of a poor environment for operating vehicles of various sorts, the use of special instrument installations in aircraft cockpits, and the exploration of sound levels in human nurseries.

- The rapid development of information, technology, including that involved in the computer sciences, e.g., parallel processing systems, will require major efforts to understand how individuals process and think about information. There is a convergence here of cognitive science and human factors research in the understanding of person-machine interactions.

- Behavioral and social sciences have contributed directly to management of the research and development process in other sciences. Existing literature has been directly related to the composition of research teams, the organizational structure of research organizations, and the relationship of R&D to other functions of a business firm, such as marketing. In some of the more innovative and productive American firms this knowledge is used routinely to guide research processes, often with direct increases in research productivity.

SCIENCE EDUCATION

APA is concerned about the future of science education at the precollege, undergraduate, graduate and postdoctoral levels. We recognize that much improvement is needed in our nation's science education activities, and we endorse the Administration's request to increase funding for the Science and Engineering Education (SEE) Directorate by 16 percent over FY 1987 appropriations to $115 million. Increased funding in this area is especially critical to restore a priority to science education programs, which were drastically reduced in FY 1982 to $20.9 million. Without adequately trained scientists and engineers today, the benefits of scientific research will not be realized tomorrow. The importance of the education of our nation's future scientists is properly reflected in NSF's proposed budget. We request that Congress support a $16 million increase for the SEE Directorate in FY 1988.

Additionally, APA is pleased with the Administration's proposal to enhance overall spending for education and human resources activities throughout NSF by $91 million in the FY 1988 budget request. This increase would raise the total spent on precollege, undergraduate and graduate programs by nearly 50 percent. In keeping with NSF's effort to augment educational support for scientists and engineers, the Administration has proposed to increase funding for undergraduate programs by $38 million and graduate and postdoctoral programs and other related activities by nearly $53 million. APA is particularly supportive of efforts to increase research experiences at the undergraduate level, enabling psychology students greater opportunities to participate in behavioral science research projects supported by NSF.

NEW INITIATIVES

The benefits of a multidisciplinary research approach to advance knowledge and stimulate scientific innovation have been well demonstrated. In order to accelerate scientific advances to improve our nation's competitive posture, the FY 1988 NSF budget invests significant resources in new science and technology centers. These new multidisciplinary centers will include several centers in the behavioral and social sciences. APA supports the establishment of these new science centers, which will expand research in important areas of psychological and social science research. For example, the proposed neurobiology centers will provide research support for the many aspects of learning, memory, and cognition.

The neurobiology of learning and memory is fast becoming one of the most active and promising research area within brain sciences today. For example, important research is being conducted on the disorders of learning and memory, which will form the basis for understanding such illnesses as Parkinson's disease and Alzheimer's disease.

Examples of research on Alzheimer's disease include investigations of the role of catecholamines and neuropeptides as well as cholinergic neurotoxicity in producing Alzheimer-related symptoms. These investigations, in part, have been stimulated by findings that Alzheimer's disease is associated with decreased cholinergic activity which in turn has led to an appreciation of the chemical basis of learning and memory, i.e., how neurotransmitters are involved in learning and memory. Since such studies involve both neurochemistry and behavior, only multidisciplinary research teams can produce the needed studies. Other research has indicated that cortical neurons are the site of pathogenesis in Alzheimer's disease. Furthermore, new drug therapies are being developed for the disease that are based on our understanding of the neural systems that subserve learning and memory.

Given the enormous complexity in conceptualizing the multiple issues and influences related to learning and memory and the neurological processes, APA supports the multidisciplinary center concept, as well as the NSF proposal to expand support for small multidisciplinary research group awards, to facilitate answers to the complex questions on learning and memory.

APA also supports the NSF proposal to develop the National Geographic Information and Analysis Center, which will seek to provide answers to important social and environmental questions based on geographical analysis and spatial statistics.

While APA is encouraged by these initiatives to establish and support new centers in the behavioral and social sciences, we are very concerned about continued support for field-initiated research at NSF. Expanded support for these centers must not drain needed resources from independent-investigator research, which has been the foundation of innovative basic scientific research at NSF. This is particularly important, now that the nation seeks to rebuild its economic productivity at home and abroad. APA recommends that support for field-initiated research be maintained and enhanced as funding and resources with NSF are increased.

APA appreciates the Subcommittee's consideration of our comments and recommendations during its deliberations on the reauthorization of NSF. We strongly believe that behavioral and social science research makes important contributions to the goal of becoming internationally competitive. We commend the Administration for its vision and its conviction that NSF has a major role in supporting basic science and technology. We urge Congress to approve the FY 1988 budgetary increases and program initiatives proposed for NSF.

FASEB FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY
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Corporate Members
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AMERICAN SOCIETY FOR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS
AMERICAN ASSOCIATION OF PATHOLOGISTS
AMERICAN INSTITUTE OF NUTRITION
AMERICAN ASSOCIATION OF IMMUNOLOGISTS

Affiliate Member
AMERICAN SOCIETY FOR CELL BIOLOGY

ROBERT W. KRAUSS
Executive Director

JOHN R. RICE, C.P.A.
Comptroller

March 27, 1987

Honorable Doug Walgren
Chairman
Science, Research and Technology
  Subcommittee
Committee on Science, Space and
  Technology
U.S. House of Representatives
2321 Rayburn House Office Building
Washington, DC 20515

Dear Mr. Chairman:

The Federation of American Societies for Experimental Biology is a nonprofit organization whose purpose is to develop and disseminate new knowledge in the life sciences through its meetings and publications. Our 28,000 members represent research, educational and clinical centers throughout the U.S. We have had 109 Nobel Laureates named from among our membership over the years.

As the Science, Space and Technology Committee approaches mark up of authorizing legislation for the National Science Foundation, FASEB expresses its support for the President's FY 1988 request for the Foundation of $1.89 billion.

As you know, the FY 1988 total represents nearly a 17% increase over the FY 1987 level of $1.62 billion. It also includes $297 million for the Biological, Behavioral and Social Sciences (BBS) Directorate, a 16% jump from the FY 87 level of $257 million, and $115 million for the Science and Engineering Education (SEE) Directorate, a 16% increase over the current level of $99 million.

We support NSF's intent to focus BBS's efforts on areas such as genetics and biochemistry, but we are concerned that a large investment in the proposed centers initiative may drain support from the individual investigator-initiated research grant, which is the backbone of any sound research enterprise. While the centers may provide unique research, training and educational opportunities in a cross-disciplinary environment, the Committee should carefully examine the budget implications of a proposal that would absorb a substantial portion of NSF resources for several years to come. In testimony before this Committee, NSF Director Erich Bloch noted that the Foundation would like to support about 70 centers in FY 1988 at a cost of approximately $3 million per center. Centers would receive support for 3-4 years, an annual outyear cost of approximately $210 million for the next several fiscal years. This is a significant outlay for the Foundation. We urge that centers in biology be regarded as experimental, with an initial investment in a small number in order to measure potential success without compromising the Foundation's ability

PUBLISHER OF FEDERATION PROCEEDINGS

to adequately support other programs.

We applaud NSF's increased efforts in the area of Science and Engineering Education. We know that NSF is faced with two very different and necessary emphases in coping with the training of future scientists: attracting young people into scientific fields and maintaining the pipeline which produces quality scientists. Under the proposed budget, the Foundation would increase new three-year graduate fellowship awards from the current level of 560 to 760 for a total of more than 1,700 new and continuing fellows. NSF also would enhance its undergraduate activities, with increased support for the Research Experiences for Undergraduates (REU) program which provides hands-on research opportunities for undergraduate students. However, as the National Science Teachers Association has noted, most children lose their interest in science by mid-grade school. If we are going to continue to adequately fill our need for scientists, we need to attract young people to science careers in the early stages of their education. This means that NSF should focus more attention on attracting young people to science careers by putting more resources into grade school-oriented programs.

In the face of the large federal deficit and the requirements of the Gramm-Rudman-Hollings budget-balancing law, new or increased federal investments must be chosen in light of current national priorities and the greatest return for the dollar spent. Since the competitive posture of the U.S. is dependent on a steady flow of new knowledge as well as an adequate supply of trained people, investments in basic research and education, such as those the President is requesting for NSF, are clearly justified. We urge the Committee to consider these points as it drafts authorizing legislation for the Foundation.

Sincerely,

Robert W. Krauss
Executive Director

APPENDIX 6

LETTER FROM NSF DIRECTOR ERICH BLOCH REGARDING THE ENGINEERING RESEARCH CENTERS, OCTOBER 31, 1986

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

nsf

OFFICE OF THE
DIRECTOR

October 31, 1986

Honorable Don Fuqua
Chairman
Committee on Science and
  Technology
House of Representatives
Washington, D. C. 20550

Dear Mr. Chairman:

In the Committee on Science and Technology Report accompanying the FY 1986 authorization of the National Science Foundation, the NSF was directed to "review the priorities for fundamental engineering research and report to the Committee by October 1, 1986, its views and justification for establishing additional centers or adjusting priorities in Fiscal Year 1987" (pages 16-17, Report 99-619).

I am very pleased to submit this report to you and would be glad to provide you with any additional information you may need.

Sincerely,

Erich Bloch
Director

Enclosure

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COMMITTEE ON SCIENCE
AND TECHNOLOGY

Report to the House Science & Technology Committee as Requested in House Report 99-619.

House Report 99-619, pp. 16-17, states:

"Thus, given the current budgetary constraints, the Committee directs the NSF to review the priorities for fundamental engineering research and report to the Committee by October 1, 1986, its views and justification for establishing additional centers or adjusting priorities in Fiscal Year 1987."

NSF Response: The establishment of additional Engineering Research Centers (ERCs) depends upon future budget growth. The FY 1987 NSF appropriation of $1.62 billion (8.9% above FY 1986) will permit the ERC program to be funded at about $30 million, up from $21.6 million in FY 1986. The FY 1987 requested level was $35 million. This funding level will permit NSF to do the following:

1) Continue to strengthen all of the existing centers through selective increases based upon ERC performance and need.

2) Start from two to four new ERCs, depending on the costs of the recommended centers. (For the 1987 competition we have received 68 proposals from 48 primary institutions and 28 states.)

Since the beginning, the strategy was to build up support for the ERC program as the Engineering budget grew. The 1985 National Academy of Engineering Report, "Guidelines for Engineering Research Centers" recommended that NSF establish 25 centers during the first five years of operation. Based upon the National need for such centers, this is still our long range goal. However, the rate of growth of the program will have to be slowed in view of budget constraints.

NSF also believes that every effort must be made not to reduce the viability of the already established centers. Even with a reduced budget we would try to maintain present award levels for the existing centers.

We share the Committee's concern that NSF must strive to maintain a proper balance between support of individual investigator projects, Presidential Young Investigator (PYI) Awards, and the Engineering Research Centers. The 1985 restructuring of Engineering provides a framework for maintaining this balance.

A prime objective is to maintain strong support for individual investigator research projects. (Because of their nature, we include PYI awards in this category.) The ERC program has grown to its present level without serious impact on the funding of individual investigators. In FY 1987 we are planning to increase support to individual investigator projects by about five percent while providing some expansion in the ERC program.

The amount requested for Base Level Support in FY 1987 is in-
ased considerably by a budget base transfer to the Coast Guard
icebreaker fixed costs. This $14.4 million transfer will be offset
about $1.5 million in icebreaker incremental costs which NSF
assume, leaving a net increase of $12.9 million in funds avail-
in FY 1987.

The third subelement under Operations Support, Major Con-
iction and Procurement, contains the largest increase for FY
7 ($11.7 million or 40.0% over FY 1986). The increase includes
0 milion to upgrade the LC-130 aircraft fleet and $3.8 million as
first increment of construction of a new science laboratory at
Murdo Station.

The bill as amended by the Committee reduced the U.S. Antarc-
Program budget level by $7.0 million from the Administration
uest of $117.0 million. This $110.0 million budget level is the
me amount available in the FY 1986 post Gramm-Rudman-Hol-
gs plan. Since the Coast Guard will assume the icebreaker fixed
sts, the funds available to NSF for the Operations Support Pro-
am will be approximately $6.0 million greater than in FY 1986
d will permit some of the necessary upgrading, replacement, and
st increases involved in maintaining a strong program.

5. ENGINEERING

mmittee View

As technology propels our economy forward the application of
ence and engineering research becomes most critical. Even
ough the United States has accomplished a great deal in techno-
ical innovation our international competitors have been even
ore successful in utilizing new technology; even though much of
has been spawned in the United States. In order to regain our
e-eminent position in the world economy we must develop new
d creative ways of applying research discoveries to commercial
d industrial enterprises. The Engineering Research Center (ERC)
ogram is the kind of multidisciplinary approach that will allow
gineering faculty and students to interact with engineers from
dustry. This strong linkage between interdisciplinary research
d education can be a catalyst for developing new ideas for appli-
ation by industry as well as enhancing the the quality of engineer-
g education.

The Committee applauds the strong management of the Engi-
ering Research Center Program as well as the overall reorgani-
ation of the Engineering Directorate. At the same time, the Com-
ittee notes that NSF plans to establish four new Engineering Re-
arch Centers in Fiscal Year 1987 in addition to the five estab-
hed in Fiscal Year 1986 and six centers in Fiscal Year 1985. Al-
hough the Committee strongly supports the research center con-
pt, the Committee also realizes continued support for the full
mplement of centers implies an obligation in future years assum-
g both the concept and the individual centers live up to anticipat-
performance and productivity. The Committee believes every
ffort must be made not to reduce the viability of the already es-
blished centers. Thus, given the current budgetary restraints, the
ommittee directs the NSF to review the priorities for fundamen-

tal engineering research and report to the Committee by October 1, 1986 its views and justification for establishing additional centers or adjusting priorities in Fiscal Year 1987.

NSF should give careful attention at this point to a productive balance in the allocation of fiscal support among individual investigator projects, Presidential Young Investigator Awards, and the Engineering Research Centers. Likewise, attention should be given to the appropriate balance between programs aimed at developing advances in design, manufacturing, computer engineering, and critical technologies. Since fundamental engineering research is as vital to economic growth as research in basic sciences, the Foundation should not lose sight of that balance.

6. ADVANCED SCIENTIFIC COMPUTING

Background

The goal of the NSF Advanced Scientific Computing activity is to provide high quality access to unique advanced computational facilities for all segments of the science and engineering basic research community. The specific objectives of the activity are to: (1) provide the large scale computational resources essential both to the research and to the training of scientists and engineers; (2) extend and develop networks and communications systems which assure access to large scale computing facilities; and (3) create computer programs for making software more portable and operating systems more user-friendly, for providing more efficient programs for scientists, and for developing means to handle, store and interpret massive amounts of data. The challenge for NSF is to establish both advanced scientific computing centers and network access, to make efficient use of existing resources and capacities, and to create facilities dedicated to meeting the computational requirements of the many science and engineering disciplines.

Currently, the centers' program focuses on providing large scale computational resources to all scientific and engineering disciplines for basic research requirements via national NSF supercomputer centers. The plan of the centers' program entailed a two phase approach to: (1) immediately provide time on supercomputers via lease agreements with existing supercomputing facilities; and (2) replace the lease plan with new national centers. In FY 1985–86, NSF acquired services from six organizations to fill the immediate large scale computational needs of researchers. These Phase I centers are located at the University of Minnesota, Colorado State University, Purdue University, Boeing Computer Services, AT&T Bell Labs, and Digital Productions.

Four Phase II national supercomputer centers are currently being established: the San Diego Supercomputer Center (University of California at San Diego); the National Center for Supercomputing Applications (University of Illinois); the John Von Neumann Center for Scientific Computing (near Princeton University); and the Pittsburgh Center for Advanced Computing in Engineering and the Sciences (near Carnegie-Mellon University and the University of Pittsburgh). In addition, an experimental supercomputer center was opened at Cornell University where access is provided to an advanced parallel system.

LETTER FROM REP. FUQUA AND REP. LUJAN REGARDING ERC'S, DECEMBER 17, 1986

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ROBERT C. KETCHAM
General Counsel
R. THOMAS WEIMER
Republican Staff Director

December 17, 1986

Mr. Erich Bloch, Director
National Science Foundation
Washington, D.C. 20550

Dear Mr. Bloch:

We appreciate receiving your report on the priorities for fundamental engineering research and plans for Engineering Research Centers (ERCs) in fiscal year 1987, as requested in the Committee's legislative report accompanying the National Science Foundation Act for Fiscal Year 1987.

While your response describes the fiscal year 1987 operating level for the ERC program and the plan for allocation of these funds, the response does not address how the National Science Foundation (NSF) will assure priorities for fundamental engineering and the balance between centers and individual investigation projects will be achieved and evaluated. The Committee requests that NSF provide more specific information in that regard. For example, the report notes that the NSF has received 68 proposals for the fiscal year 1987 ERC competition. However, the report does not describe what approaches were used to assure that priority engineering research issues would be addressed by the proposals received. To what extent will the review and selection of new ERCs reflect the needs in critical fields of engineering, rather than a case review of each proposal?

With respect to existing ERCs, the Committee would like elaboration on the criteria used to evaluate their performance. For example, what does NSF regard as a "successful" ERC? To what extent is the management of existing ERCs examined and how is productivity at these centers defined and measured? Are there specific fields of engineering for which centers ought to be established because of their technological promise or fundamental research needs?

In addition, your report notes the National Academy of Engineering (NAE) 1985 report recommended that NSF establish 25 centers. Has this strategy been re-evaluated in light of NSF's experience with the existing 11 centers? The Committee would note the example of the establishment of supercomputer centers: while the Bardon-Curtis report recommended the establishment of 10 such centers, a re-evaluaton of the need, the technology, the information and communications field, as well as the promises of networking renders this recommendation obsolete.

Mr. Erich Bloch
December 17, 1986
Page 2

Finally, the Committee would like to know NSF's rationale or policy with respect to the balance between ERCs and support of individual investigators. The Chairman of the committee that prepared the NAE report, Dr. Dale Compton, in his testimony before the Subcommittee on Science, Research and Technology, February, 1986, stated "The issue, it seems to me, comes down to quality and the funding level, and ensuring that they are funded at a level on which they are viable. So the number should not increase at the expense of viability of the individual." What balance would be appropriate between the ERCs and individual investigators and what factors must be considered in maintaining a viable engineering program?

Given the increased importance attached to fundamental engineering research by the Congress and the NSF, we are vitally interested in the future plans and priorities of these programs. In order that the Committee can conduct a thorough review of the fiscal year 1988 budget request for the NSF, we would appreciate receiving a response to these questions by January 28, 1987.

Thank you for your attention to this matter.

Sincerely,

Don Fuqua
DON FUQUA
Chairman

Manuel Lujan Jr.
MANUEL LUJAN, JR.
Ranking Republican
Member

FL/BII

Letter From NSF Director Erich Bloch in Response to December 17, 1986 Letter From Rep. Fuqua and Lujan

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

nsf

OFFICE OF THE
DIRECTOR

February 18, 1987

FEB 1 9

Honorable Robert A. Roe
Chairman, Committee on Science
and Technology
U.S. House of Representatives
Washington, D. C. 20515-6301

Dear Mr. Chairman:

Your December 17, 1986, letter raised a number of issues about our engineering program. Each has been a matter of intense study and consideration at the Foundation for the past three years. We made this examination because the National Science Board, the National Academy of Engineering and the President's Science Advisor had called for NSF to play a much more active role in the support of engineering research and engineering education.

There were a number of concerns, including: (1) an overemphasis on the theoretical and analytical aspects of engineering; (2) too little emphasis on technology-driven fields such as design and manufacturing; (3) a lack of cross-disciplinary research capability at our engineering schools; (4) the need to build an infrastructure of faculty and facilities needed to conduct research in emerging engineering areas such as biotechnology and lightwave technology; and (5) the need to strengthen interaction between industry and universities in both engineering research and engineering education.

Except for a small Industry/University Cooperative Research Centers program ($3.0 million in FY 1987), NSF's engineering research program did not adequately address any of the above concerns.

At the beginning of 1985, NSF established a new engineering program and a revamped organization structure was put in place. The actions we have taken are aimed at strengthening engineering research and engineering education. Taken together, they represent a broad thrust of support that addresses the five areas of concern listed above, and they extend the coverage of NSF support in core areas of engineering as well.

It is our goal to move ahead with the new thrusts in engineering while strengthening fundamental research conducted through individual research project grants.

With this as background, I would like to address the specific questions raised in your December 17 letter.

Q. To what extent will the review and selection of new ERCs reflect the needs in critical fields of engineering, rather than a case review of each proposal?

A. A two-stage review is used in the selection of ERCs. The first involves sixty or more outside expert reviewers who assess proposed topic areas for their potential importance in terms of the goals of the ERC program, including their relevance to industry needs. About half of the panel members are from industry.

A high-level ERC Panel, consisting of twelve members, nine of whom are currently from industry, reviews the recommendations of the preliminary panels and identifies those which address needs in fields that are critical to future economic competitiveness.

NSF has received 310 ERC proposals requesting about $4.5 billion in support in the first three rounds of competition. The topics cover nearly every critical area of engineering research that has the potential for contributing to economic competitiveness.

We are concerned, however, that we get ERC coverage in the most critical areas. For that reason, the Foundation is considering encouraging proposals in specific areas in later competitions.

Q. What does NSF regard as a "successful" ERC?

A. We are looking for progress as measured against the following ERC program goals:

1. Develop new knowledge in areas that will help industry improve its economic competitiveness;

2. Stimulate cross-disciplinary research among university faculties;

3. Provide graduate and undergraduate engineering students with cross-disciplinary research and related experience that will better prepare them to be engineering practitioners;

4. Create new levels of expertise in engineering systems; and

5. Enhance industry/university research collaboration.

More specifically, significant indicators of success for an Engineering Research Center include: (1) evidence that the Center is making good progress on its research goals and that its research agenda has the potential for making a significant contribution to technological advancement; (2) establishment of effective cross-disciplinary research teams; (3) development of various education-oriented activities designed to better prepare students to be engineering practitioners; (4) significant industry interest and collaboration in the Center's research and education programs; and (5) effective integration of the Center into the University System.

As the Centers mature, they also are expected to play a significant role in technology transfer.

Q. How is productivity at these Centers defined and measured?

A. Productivity is measured through a number of management practices and procedures developed especially for the ERC program. Annually, each Center is required to submit to NSF a written progress report on its operations for the year and plans for the upcoming year. This includes data on specific indicators of activity that are compiled in a data base for all the ERCs.

In addition, Technical Advisory Committees (TAC), which consist of NSF staff members who are expert in an ERC's area of research focus make annual site visits to the Centers. The purpose of these visits is to assess the research in progress and evaluate the Center's progress in achieving its goals. TAC members are selected from all NSF Directorates, not just Engineering.

Information obtained through site visits and other management oversight activities, are the basis for making annual evaluations of the productivity of the ERCs.

During the third year, each ERC will receive a major review by a team of academic and industry experts. The purpose of this review is to determine the performance of the Center through an assessment of research progress to date, and its progress in fulfilling the goals of the ERC program. At this point, a decision is made to either continue the Center or phase it out over the next two years.

I want to raise a word of caution in this general area of evaluation. Evaluations must be done with wisdom and an appreciation of the engineering education and research the ERCs have undertaken.

The ERCs are attempting to bring about a cultural change in the universities that will stimulate the conduct of cross-disciplinary research focused on areas of industrial interest. This is a difficult task but an extremely important one, if we are to move engineering forward.

Q. Are there specific fields of engineering for which Centers ought to be established because of their technological promise or fundamental research needs?

A. Our current ERCs, as well as the majority of the other proposals we have received for the ERC competition, have been in areas that are important to advancing research and strengthening the Nation's technology base. Nevertheless, to avoid a situation where a particularly promising area might be missed, NSF is, as mentioned above, considering calling attention to particularly promising research topics in the FY 1988 ERC Program Announcement.

Q. Your letter notes that the National Academy of Engineering (NAE) 1985 Report recommended that NSF establish 25 Centers. Has this strategy been reevaluated? Will technological change reduce the need for ERCs as it did in the case of Supercomputer Centers?

A. The number of ERCs need not be determined by major changes in specific technologies, i.e., faster, smaller computers. The Centers are operating in broad areas of research and are flexible enough to respond to developments at the cutting edge of technology. Moverover, ERCs have a very different purpose than Supercomputer Centers, and technological change does not have a similar impact on them.

In addition, each Center provides for the participation of engineers and scientists from industrial organizations in order to focus the Center's activities on current and projected industry needs and to enhance education on the systems aspects of engineering. We believe that the cross-disciplinary nature of the Centers and their interactive mode with industry will avoid program obsolescence.

Overall, we see an even greater need for engineering schools to conduct cross-disciplinary research relevant to economic competitiveness.

Q. The Committee would like to know NSF's rationale or policy with respect to the balance between ERCs and support of individual investigators, and what factors must be considered in maintaining a viable engineering program.

A. The balance between ERCs and the support of individual investigators is based on a planning process that synthesizes inputs from a variety of sources. These include the National Academy of Engineering, the Engineering Directorate Advisory Committee, industry and university engineering researchers and educators, the Foundation's engineering staff, our Executive Council, the National Science Board and others. This is an iterative process that surfaces many competing priorities, program needs, and opportunities.

The planning process is the basis for our program plan which is now incorporated in our FY 1988 Budget to Congress.

As our Budget indicates, at present levels, we have determined that the balance between ERCs and support of individual investigators in engineering should be $1 of Center support for every $4 in Individual Research Project Support.

In our longer range planning, and based on the considerations and recommendations obtained in the planning process outlined above, it is our position that the appropriate balance between ERCs and Individual Research Project Support should be $1 of Center support for every $3 for Individual Research Project Support. That position assumes an increased level of funding for both categories of support.

With regard to factors that are considered in maintaining a viable engineering program, let me list six which are key in the development of our program plans for Engineering. The program must:

- Strengthen existing engineering knowledge bases and build new ones in fields that lack them.
- Strengthen the engineering research and educational infrastructure.
- Pursue research opportunities in innovative areas with high potential for long-term economic and technological impact.

- Leverage the use of resources for engineering research by promoting cooperation among academia, industry, and governments.
- Promote the systems and cross-disciplinary approach to engineering.
- Help find ways to transfer research results into economic enterprises.

I hope that these answers will prove helpful in your continuing review of NSF's programs.

Sincerely,

Erich Bloch
Director

Identical letter sent to Honorable Manuel Lujan, Jr.

APPENDIX 7

Letter From NSF Director Erich Bloch Regarding the Status of NSF Support for the National Supercomputer Center

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

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OFFICE OF THE
DIRECTOR

RECEIVED
MAY - 6 1987
COMMITTEE ON SCIENCE
AND TECHNOLOGY

Honorable Robert Roe, Chairman
Committee on Science, Space and Technology
U. S. House of Representatives
Washington, D. C. 20515

Dear Mr. Chairman:

At recent hearings on the programs of the National Science Foundation, we discussed the status of the Foundation's support for its national supercomputing centers and the interim resource centers. Because this matter is of such great interest, I want to provide a more comprehensive statement, beginning with a short background to place the matter in context.

Background

The foundation of NSF's supercomputer initiative was laid in 1982-83 with several studies and reports by panels of experts in the field of advanced scientific computing. The most well-known of these was chaired by Dr. Peter Lax, member of the National Science Board and Professor at the Courant Institute of New York University. Scientists and technical experts from academia, industry, and the government participated. Two major problems were identified:

- Effective access to supercomputers as research tools was severely limited to a few science and engineering disciplines, i.e., fusion energy, atmospheric sciences and nuclear weapons research; young researchers were not being trained in advanced computing.
- The capacity of the current generation of supercomputers was several orders of magnitude too small to address problems of urgency in science, engineering, and technology.

In response, the Foundation formed a new office in early 1984. Consistent with the Lax report, its goals were broad: to address the access problem, to increase the awareness of the potential of supercomputing within the national research community through training and educational activities, to foster research in computational mathematics, software, and numerical algorithms necessary to get the most out of existing supercomputer systems, and to encourage the development of new and more advanced technology within the U.S. computer industry.

NSF Centers Program

To meet the first goal quickly, NSF acquired supercomputer time from several academic and industrial sites; these were the Phase I, or resource, centers. As a long-term strategy to achieve the overall goals, a national competition was held to establish NSF national supercomputing centers; five centers were chosen. A key selection factor was the capability and interest in performing research to advance the state of advanced scientific computing. Providing the most advanced computer cycles to the national research community is only part of the national centers' responsibility. It is the associated research in new software, algorithms, architectures, programming tools, and networking, for example, and the training/educational activities that make these centers unique national resources.

An important aspect of effective access to NSF supercomputers is a national academic research network. The NSFNET made its first awards about a year ago and expects within the next two years to have connected over 100 of the top research institutions in the U.S. with robust and high-speed communications to local campus networks and then to researchers' desks.

Finally, NSF has programs to support computational science and engineering distributed throughout the NSF. This effort is new in 1987 and continues in Fiscal Year 1988.

Termination of the Phase I Resource Center Program

Let me return to the focus of this letter - the Phase I resource centers. Since the inception of the NSF advanced computing program in 1984, we have been very clear that the resource centers were a stopgap measure until our national centers became operational. This policy was reviewed and reiterated by resolution of the National Science Board at its November 1986 meeting:

> RESOLVED, that it is the sense of the National Science Board that the Phase I Resource Centers supported through the Advanced Scientific Computing Program should be phased out in FY 1987 and that the resources used to support them be directed to the NSF national supercomputing centers and, where appropriate, to the purchase of unique computing time from industrial or academic vendors.

Consistent with this policy, the Foundation has terminated its resource center program. As I stated above, we expect leadership in a number of areas at the national centers and support of these centers at the leading edge will be our primary commitment.

However, with the rapid pace of change in computing technology, there may be cases where NSF researchers justify the need for access to an advanced computing capability which is not available at an NSF national center. In such instances, and if sufficient funding is available, the NSF will provide support for these requests through the submission of proposals either to the Division of Advanced Scientific Computing or to the NSF disciplinary programs. These proposals will be considered under the normal proposal review mechanisms.

Transition to National Centers

In June 1986, the last two NSF national centers became operational. Three centers have already upgraded their supercomputer systems which has allowed them to meet the growing demand for supercomputer resources. Over 2,000 research projects are being supported; new allocations are made every day. Additional upgrades in facilities and staff will be necessary in the future if these centers are to develop the research capabilities originally envisioned. We review these centers yearly; both the review teams and the research community are enthusiastically supportive of the facilities and services that are provided.

With the national centers providing quality services, NSF began transferring researchers using the resource centers to the national centers early in 1986. Nearly 800 researchers have completed the transfer successfully. Most recently, we have been completing the transfer from the center at Minnesota. It is my feeling that the transfers have been handled smoothly and with a minimum of disruption to research. There are always difficulties associated with such a move, but our actions have been consistent with our plans and I believe most researchers will benefit in the long run.

There has been talk that NSF has "shut down" the resource centers. It is certainly not the case that NSF would wish to deny access to these centers. They continue to operate and provide service to many researchers. As quality research institutions, the resource centers are included in NSF's national digital network plan. And, as I mentioned above, the Foundation remains open to requests for support for access to unique resources.

In addition to funds for the national centers, the 1987 NSF budget requested funds to acquire access to such unique resources. One or two of the resource centers could have received support throughout 1987 under this new program. The actual budget, however, fell short of the amount requested and so all NSF grantees completed the transition to the national centers. Even with a reduced budget, $1.4M has been spent at the resource centers in 1987 during the transition period.

NSF Commitment to National Centers

NSF takes great pains to insure the involvement of the research community in our planning processes. In addition to the oversight provided by the National Science Board, you know of the oversight provided by the National Science Board, you know of the NSF merit review system; input from this process was an important part of the decision to award the national computing center contracts. Earlier, I mentioned our yearly reviews at each center. These reviews include researchers and technical experts from academia, government and industrial laboratories. We also have a committee of researchers which meets twice yearly at NSF to provide advice and policy guidance for our program in advanced scientific computing.

The national research community is also represented at each of our national computing centers. The San Diego Supercomputer Center and the John von Neumann Center in New Jersey are in fact consortia representing nearly 40 universities across the country. These universities contribute to the management and policy-making at these centers, including the allotment of supercomputer resources. The other centers in Pittsburgh, at the University of Illinois and at Cornell University have linkages with about 30 other university affiliates who also participate in the centers' operation. The effect of all these levels of review is that the national academic research community has a strong and direct voice in the operation and policies of the national centers. This is by design and an important part of NSF's management practice.

Finally, I am most concerned about the possibility of a tax on the national centers in order to continue support for the resource centers. I am not in favor of the idea of diluting the NSF commitment and impact by expanding the number of NSF national or resource centers. The national centers are highly leveraged - NSF funds only about 60% of the costs - with very tight budgets; we are relying on them to find industrial partners to contribute 10% of the necessary operating funds and to seek additional state and local funding. They need a stable and predictable funding environment consistent with the funding targets included in their contracts with NSF. The budgets of the national centers must not be seen as a well of money to support additional unplanned centers. Such a tax would prevent the vital facility and staff upgrades I mentioned earlier. In addition, we do not want to give the impression that NSF's enthusiasm for its national centers is waning. This would make the involvement of new funding sources difficult.

Thank you for the opportunity to comment on one of the Foundation's most exciting programs. I hope you will agree that we have a solid base of accomplishments to build upon in the future.

Sincerely,

Erich Bloch
Director

cc: Honorable Manuel Lujan

APPENDIX 8

Letter From NSF Director Erich Bloch Regarding NSF Support of Centers and Individual Projects, March 12, 1986

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

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OFFICE OF THE
DIRECTOR

March 12, 1987

RECEIVED
MAR 16 1987
COMMITTEE ON SCIENCE
AND TECHNOLOGY

Honorable Robert A. Roe
Chairman
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

As the Committee requested in its June 4, 1986 report on the National Science Foundation Authorization Act for Fiscal Year 1987 (Report 99-619, page 10), I am pleased to provide some perspective on trends in NSF support of centers, other collaborative research, and individual investigator projects.

Determining the appropriate balance among these mechanisms for the support of research is a central and constant concern for the Foundation. It receives careful consideration at every level, from program level to senior management and the National Science Board, and is a major element in the deliberations of all of our advisory bodies.

A graph showing the distribution among the various categories of awards for the past three years is enclosed (Enclosure A). It illustrates several important points. First, support for individual efforts remains the principal funding mode of the Foundation, representing about 60% of the 1987 plan. In dollars, funding for individual awards over the three-year period has increased by about $60 Million. Funding for collaborative research, including centers, is a relatively small but increasing portion of our budget, growing from 7% in 1985 to about 11% in 1987. Funding for large scale national facilities such as telescopes and accelerators remains steady at about 8% of the total.

These proportions, and the changes among them, reflect our judgments about the dynamic forces in today's research as well as the fundamental relationships which underpin the long-term health and vitality of the enterprise.

We agree with the Committee's observation that individual investigator awards promote the flexibility and spontaneity which often foster scientific breakthroughs. Such awards, as already noted, constitute by far the largest portion of the NSF budget, and reflect our commitment to maintaining the basic research capability of the Nation across the full spectrum of science and engineering disciplines.

Over the past generation, however, much basic research has moved in the direction of collaboration and concentration of resources. In part, this trend is a response to the increasing cost and sophistication of instrumentation, which requires sharing at departmental, institutional, or even regional or national levels, if laboratories are to be equipped to state-of-the-art standards.

Much of the change, moreover, reflects shifts in the nature of scientific inquiry itself. Technologies such as satellite communication and large scale computing enable scientists to work with data sets of great size and complexity; these and other tools have opened completely new avenues of experimentation which require collaborative approaches. The scientific forefront is increasingly at the intersections of disciplines: astrophysics, biotechnology, atmospheric chemistry, computational science and engineering, materials science and engineering are examples of "fields" which are at the leading edge of modern scientific effort and require expertise from more than one discipline.

This trend is reflected in the growth of collaborative research as a fraction of the National Science Foundation budget in recent years. Collaborative efforts themselves cover a wide range: some are little more than a loose association of individual investigators who share an interest in a particular phenomenon or problem; others involve large-scale facilities and instrumentation and regional, national or even international management and coordination.

The centers programs advanced by the Foundation in recent years lie essentially at the middle of that spectrum. Engineering Research Centers, Biotechnology Centers, and the Basic Science and Technology Centers proposed for Fiscal Year 1988 are a natural evolution of the trend toward interdisciplinary collaboration to address scientific and engineering problems of particular complexity and urgency. In addition, centers provide unique opportunities for education and technology transfer, involving graduate and undergraduate students in forefront research, and engaging the research capabilities and needs of industry and state and local governments in active partnerships with universities.

As I indicated at the outset, the proper balance among these modes of supporting and conducting research can never be static. It must evolve with the needs of science itself, as well as in response to the needs of the Nation. For this reason, assessing program balance is an ongoing evaluative process for the Foundation, characterized by extensive use of advisory mechanisms within disciplines and constant review and discussion at other levels.

Every division of the Foundation seeks external program advice through standing advisory groups and panels, most of which meet several times annually. Ad hoc advisory groups are frequently convened to discuss new programs, or proposals to change NSF policies or procedures. Every NSF program is subjected to formal assessment by an external committee of experts once every three years. The question of balance is one of the central preoccupations of all of these reviews.

In addition, the National Science Board (NSB) has two operating policies which provide a framework for "center" activities, and is currently engaged in a detailed analysis of this important and timely issue.

The first policy concerns the balance between so-called "big" and "little" science. As explained in Enclosure B, the issues involved here are similar to those having to do with the standard grant/centers mix. In brief, the policy calls for balance to be struck within disciplines by full use of the various disciplinary advisory mechanisms. It requires that plans for proposed "big science" undertakings be accompanied by an impact assessment that looks at opportunity costs. This written analysis is incorporated in a project plan which must be approved by the NSB.

A second important policy concerns priorities in budgeting and related programming actions between research proposed by an individual and that proposed by a group. The Board adopted a policy (NSB/Res-81-48, Enclosure C) wherein research proposals are to be "judged on the likely quality of the proposed science" rather than in terms of the individual or corporate nature of the activity.

An ad hoc NSB Committee on Centers and Individual Investigator Awards, chaired by NSB Vice-Chairman Dr. Charles E. Hess, is currently examining the relative merits of centers and individual investigator awards, including the issue of defining a proper balance. I anticipate receiving that Committee's report by mid-summer, and will be pleased to provide you with the results of the Committee's deliberations at that time. In the meantime, if I may provide any further details, please do not hesitate to call on me.

Sincerely,

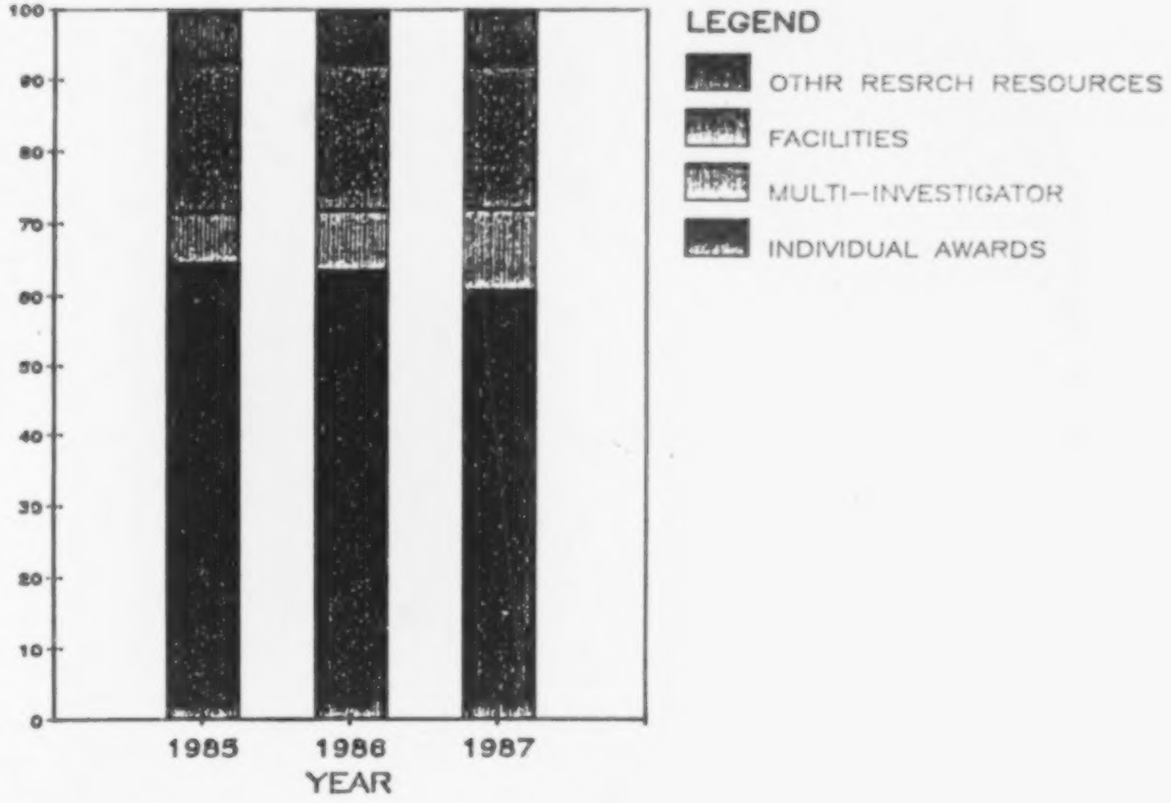
Erich Bloch
Director

Enclosures (3)

cc: Honorable Manuel Lujan, Jr. w/Enclosures

Enclosure A.

PROJECT BALANCE
1985 – 1987



PROJECT BALANCE DEFINITIONS

Individual Awards - individual investigator awards, typically funding three or fewer principal investigators and totalling under $300,000.

Multi-investigator - research efforts including more than three investigators. These include larger, collaborative projects such as Engineering Research Centers, Long-Term Ecological Research projects, university physics groups, Materials Research Labs and the larger continental lithosphere projects.

Facilities - large, multi-user national facilities, including the National Magnet Laboratory, telescopes, the academic fleet, supercomputer centers and the Cornell Electron Storage Ring.

Other Resources - awards which strengthen the research infrastructure, such as surveys, analyses, travel grants, grants for conferences and symposia, support for collections, databases, equipment-only awards and postdoctoral fellowships.

Enclosure B.

NSB-79-65

January 19, 1979

"BIG SCIENCE" POLICIES AND PROCEDURES STATEMENT UNANIMOUSLY ADOPTED BY THE NATIONAL SCIENCE BOARD AT ITS 203RD MEETING ON JANUARY 18-19, 1979

A. DEFINITIONS

1. "Big science" projects, as viewed by the National Science Foundation (NSF), are those having all of the following characteristics:

   a. Large-scale commitment of financial resources;

   b. Investment of capital in facilities and major equipment;

   c. A duration of several years or more; and

   d. Continuing expenditures for maintenance, replacement, operating costs, and research budgets.

   Size in this case is both absolute (cost and complexity of the effort) and relative (share of resources devoted to a particular field and share of the Foundation's overall resources).

2. With regard to funding implications, "big science" projects can be viewed as two types:

   a. Those that can be accommodated within anticipated reasonable budget levels for a field of science supported by NSF, or within anticipated overall NSF budget levels; and,

   b. Those very exceptional projects that because of their cost, complexity, and/or the involvement of other Federal agencies cannot reasonably be supported within anticipated overall NSF budget levels and thus should be proposed to the President and the Congress for consideration over and above the NSF budget.

B. POLICY FRAMEWORK

1. Balance between "big science" and "little science" in any one field should be considered in the first instance by divisions and advisory groups cognizant in that field, but balance across the Foundation is the responsibility of the National Science Board (NSB) and the Director.

2. The program plans and cost estimates for each proposed "big science" project should be reviewed by the cognizant advisory groups, NSF staff, Director, and the National Science Board as early in the planning and budgeting cycle as possible, i.e., for any given budget year, in the long-range planning meetings leading up to the budget formulation for that year.

3. Whenever possible, funding of a proposed "big science" project will be accommodated within the budget for a given discipline (based on reasonable out-year projections).

4. No specific percentage of the projected budget for a discipline should be established as a limit or control on "big science" projects; instead, the balance of "big science" and "little science," as well as the degree of "flexibility" within a discipline resulting from long-term commitments, should be reviewed periodically by the cognizant advisory groups, NSF staff, the Director, and the National Science Board, particularly when new "big science" projects are proposed.

5. When the Director and the National Science Board determine that funding of a new "big science" project cannot be accommodated within the anticipated budget for a given discipline, the project will be considered for funding (a) within anticipated overall NSF budget levels, or (b) as a special item over and above anticipated NSF budgets. Some of the factors to be considered are: the overall size and duration of the project, its relation to activities of other nations and agencies, including their ability to assist in the funding, the degree of "flexibility" in anticipated NSF budgets, and Presidential and Congressional policies.

6. No specific percentage of the Foundation's budget should be established as a limit or control on the overall number of "big science" projects. Instead, the balance of "big science" and "little science" across the Foundation, as well as the degree of "flexibility" in the budget resulting from all long-term commitments, should be reviewed by the Director and the National Science Board each year in connection with long-range planning.

7. All "big science" projects proposed to start in any given budget should be reviewed at the same time, and the National Science Board should establish priorities based on prior review by, and recommendations of, the Director. The phasing of projects over several budget years will be an explicit consideration.

8. The plans and estimates for any given "big science" project should also be reviewed by the Director and the National Science Board again in connection with the budget formulation stage of the cycle, and, after the budget has been appropriated, again through the Director's Action Review Board and the National Science Board approval cycle.

C. PROCEDURES

1. For the annual long-range planning cycle, Directorates proposing new "big science" projects should submit a project development plan (following a format to be designed) that briefly describes:

    a. The scientific needs for the project, including criticality, impact on the field and neighboring fields, comparison with principal alternatives, probability of success, and the size of the scientific community involved;

    b. The views of the appropriate advisory group concerning:

        (1) the priority of the project;

        (2) its effect on the balance and concentration of "big science"/"little science" within the field

under varying resource assumptions (including essentially level budgets); and

(3) the opportunities that would be foregone by undertaking or not undertaking it;

c. Estimates of all initial and out-year costs, including those for facilities, management and operation, maintenance, associated equipment and implied grant support levels; and the basis for the cost estimates and the estimate of project lifetime;

d. Principal management, procurement and legal considerations, such as competition, timing, appropriate legal instrument, management and organizational structure;

e. Origin and periodicity of management and fiscal reports, and timing and other considerations for evaluating the project; and

f. Identification of principal phases or milestones, including the point at which the project as a whole, or phases thereof, will be concluded.

2. Once the program development plans have been approved by the Director and the National Science Board, the plans will be updated whenever a significant shift in the terms or funding of the project is contemplated, and in any event the plans will be updated at least once a year in connection with the spring review of the Foundation's multi-year plans and estimates.

3. The approved program development plans will be used as the common basis for responses to the Congress, the Office of Management and Budget, the Office of Science and Technology Policy, and other external parties.

EXCERPT FROM OPEN SESSION MINUTES OF 31ST ANNUAL (226TH) MEETING
MAY 21-22, 1981

Enclosure C.

b. Policy on Principal Investigators

The Chairman reminded the Board of its discussion at the February long-range planning meeting regarding the priorities to be followed in the selection of research proposals for support. As a result of that discussion, the Chairman had requested Dr. Slichter to draft a policy statement to clarify the Board's position on this issue. In response to the Chairman's request, Dr. Slichter summarized that portion of the Board's February discussion and wrote a proposed resolution for Board consideration at this meeting. The Chairman then distributed this document via NSB-81-241 and requested Board Members to study it and be prepared to consider it at the Friday portion of the meeting.

The Chairman stated further that this document was discussed by the Executive Committee which determined that it was ready for Board consideration. He noted that the Director informed him that the formal NSF policy document which describes the criteria for NSF support of research projects should be revised by the Board in the near future. Thus, the Chairman suggested that the proposed policy statement prepared by Dr. Slichter, if accepted, might be viewed as a policy that is a sense of the Board.

The Board continued its discussion of the draft statement on a policy for selection of research proposals for support. It was decided that the term "block grant" is misleading and does not refer to a specific formal type of NSF grant and, therefore, should be deleted. The Board then took the following action:

NSB/Res-81-48

The Board unanimously CONCURRED that the following statement, as amended, be adopted as being the sense of the Board:

The National Science Board has examined the merits of various mechanisms of assigning priorities in budget planning. In particular, it has re-examined whether or not it should assign different priorities to proposals of equivalent scientific merit depending on whether research proposals are initiated by individual investigators or by groups of investigators. A comparison of the research results which have emanated from the two types of approach indicates that each is effective, and the choice of which approach is appropriate seems to be dependent on the actual science to be done.

The policy of the Board will be that research proposals be judged on the likely quality of the proposed science, not on whether the proposal was submitted by a single investigator rather than a group of investigators.